E9

EMD

OPERATING MANUAL

E9 LOCOMOTIVES

GENERAL MOTORS
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GENERAL MOTORS
LOCOMOTIVES

DIESEL LOCOMOTIVE
OPERATING MANUAL
NO. 2316

for

MODEL E9

With Vapor Car Steam Generator

SEPTEMBER, 1954

ELECTRO-MOTIVE DIVISION
GENERAL MOTORS CORPORATION
LA GRANGE, ILLINOIS, U.S.A.

PRINTED IN U.S.A.

INTRODUCTION

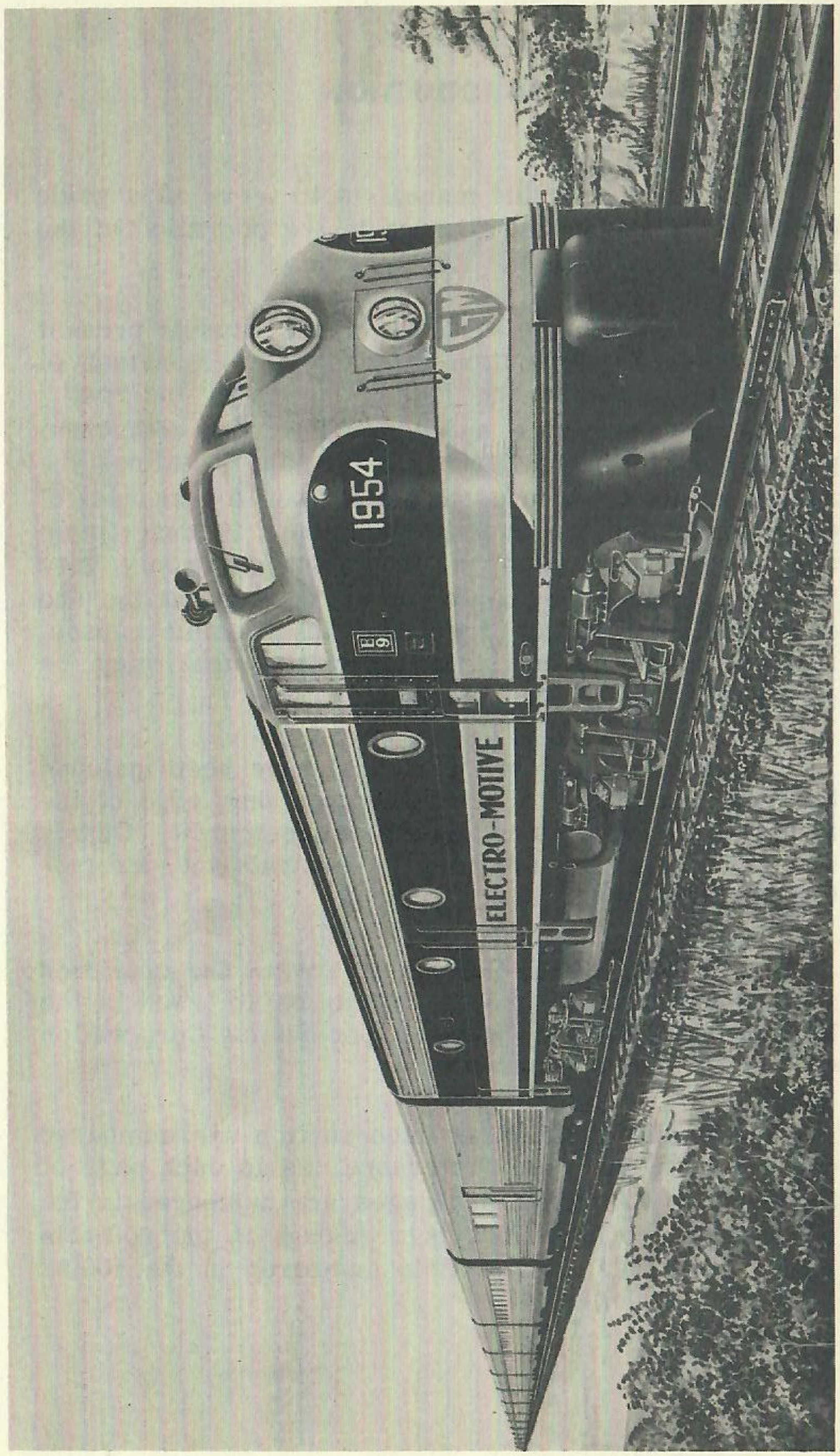
The purpose of this manual is to serve as a guide for railroad personnel engaged in the operation of the Electro-Motive 2400 HP E9 locomotive.

The first three sections of the manual present the necessary information to enable the engineman to successfully operate the locomotive "over the road." A general description and location of the component parts is contained in Section 1. Section 2 outlines the recommended procedures to be followed for successful operation of the locomotive equipment. A description and general operation of the most commonly used "extras," including dynamic brakes, is found at the end of Section 2. Section 3 outlines the possible causes, location, and correction of difficulties that may be encountered while "on the road."

Sections 4 and 5 of the manual have been included for those who desire a more thorough knowledge of the locomotive's Systems and Electrical equipment. Charts and wiring diagrams are used to illustrate the descriptive material.

Section 6, Steam Generator, covers the operation and troubleshooting procedures to be followed if the locomotive is equipped with a Vapor Heating Corporation OK series steam generator.

Principal articles of each section are numbered consecutively for ready reference, as is each page of the section. Articles and pages are numbered in the 100 series type of numbering. A page in the 400's is in Section 4 as is any article numbered in the 400's.



GENERAL DATA

Weight (fully loaded)	
"A" Unit (approx.)	316,500 lbs.
"B" Unit (approx.)	308,300 lbs.
Weight on Drivers	
"A" Unit (approx.)	210,750 lbs.
"B" Unit (approx.)	207,500 lbs.
Fuel Oil Capacity (per unit)	1,200 gal.
Lube Oil Capacity (per engine)	165 gal.
Cooling Water Capacity (per engine) "G" Valve Level	200 gal.
Steam Generator Water Capacity,	
Basic	1,350 gal.
With Hatch Tank	1,950 gal.

Gear Ratios and Speeds

Gear Ratio	Cont. T.E.	Min. Cont. Speed	Max. Speed
52/25	19,500 lbs.	37 MPH	117 MPH
55/22	23,500 lbs.	31 MPH	98 MPH
56/21	25,000 lbs.	29 MPH	92 MPH
57/20	27,000 lbs.	27 MPH	85 MPH

Sand Capacity (per unit approx.)	22 cu. ft.
Number of Drivers (per unit)	4 pair
Wheel Diameter	36"
Truck Centers	43'
Truck Rigid Wheelbase	14' 1"
Minimum Curve Radius	274' (21°)
Center of Gravity above Rail (approx.)	60-1/2"
Length: Between Coupler Pulling Faces	70' 3"
Height: Over Horns	14' 10-1/2"
Width: Outside Grab Irons	10' 8"

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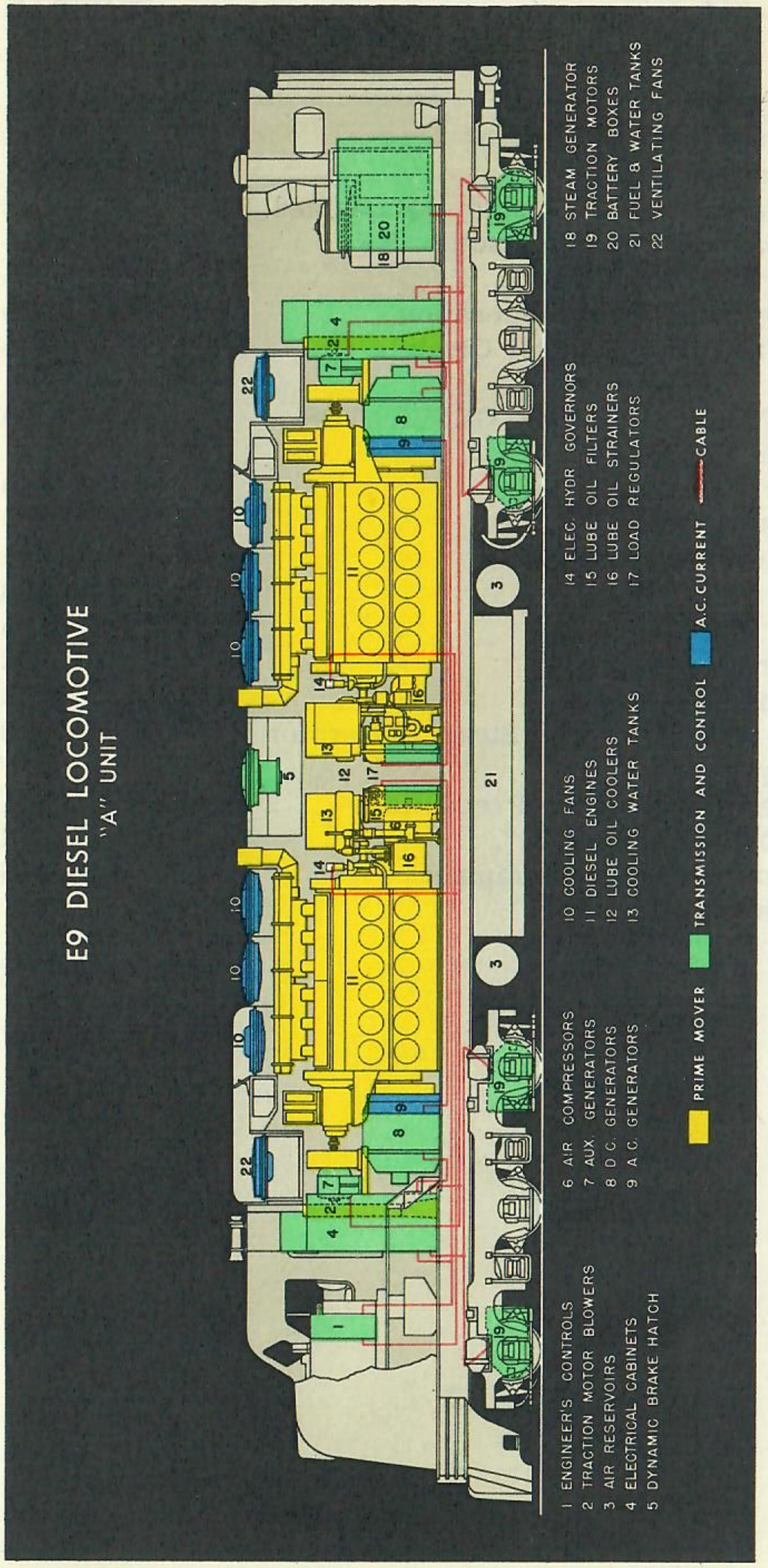
E9 DIESEL LOCOMOTIVE
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22 VENTILATING FANS
PRIME MOVER
TRANSMISSION AND CONTROL
A.C. CURRENT
CABLE

General Arrangement
Fig. 1-1

SECTION 1

GENERAL DESCRIPTION

A description and general location of equipment on the basic E9 locomotive is given in this section.

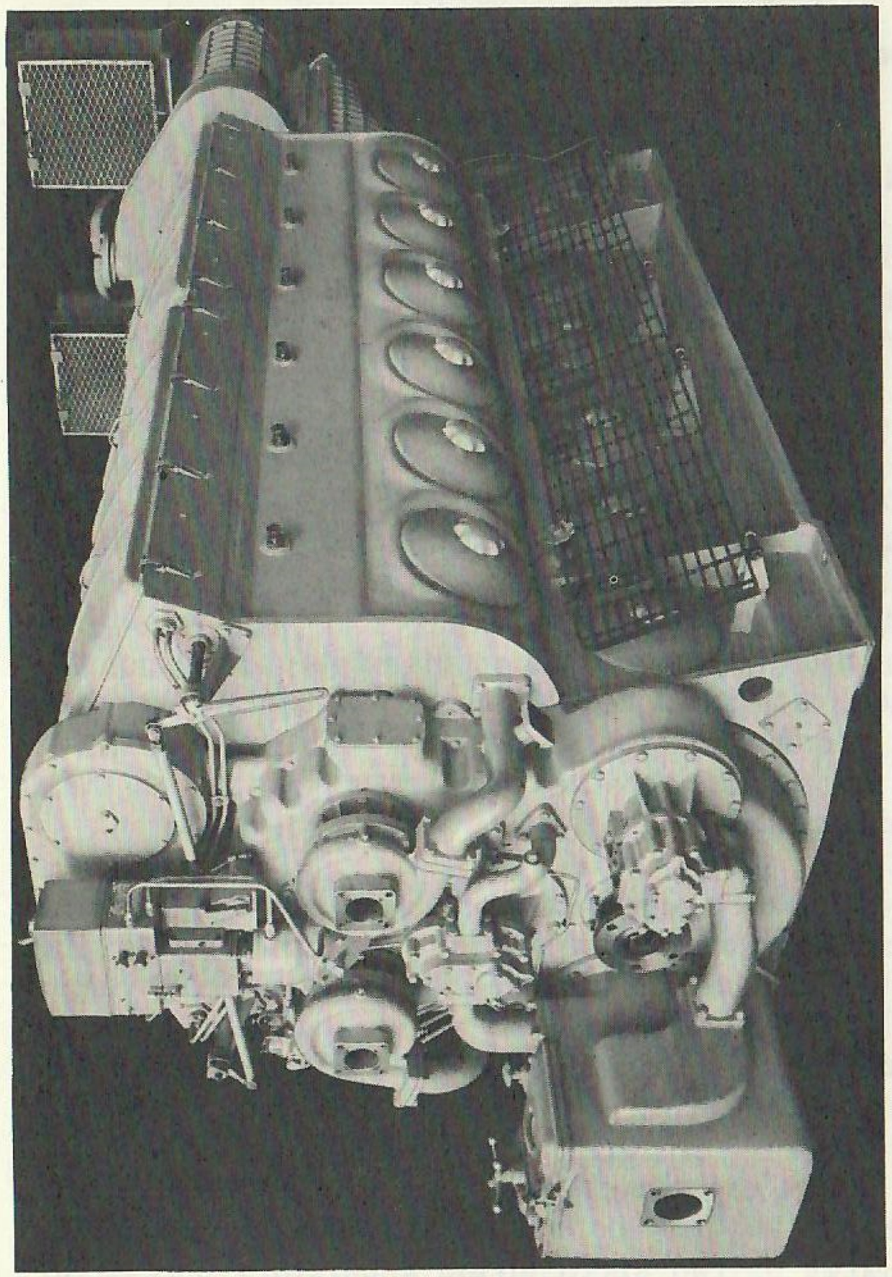
A locomotive consists of one or more units rated at 2400 horsepower each. The units which are equipped with an operating cab are designated "A" units; those without cabs as "B" or booster units. Multiple units may be used, depending on the horsepower and operating requirements.

Each unit contains TWO independent power plants. Fig. 1-1. Each power plant consists of a Diesel engine, air compressor, main generator, alternator, auxiliary generator, and electrical control cabinet, and powers two traction motors in the six-wheel truck which is located directly under each power plant. The horsepower output is determined by the engineman's throttle position. An automatic load regulation system makes the power plant produce a fixed horsepower which is constant for each particular throttle position, regardless of train speed.

All power plants are normally under control of the engineman from his cab control station. Any power plant may be "isolated" or removed from cab control by opening the isolation switch. Its engine will then run at idle speed without making power, or may be stopped completely, if desired.

Steam generators for train heating are located in a separately enclosed compartment at the rear of the unit. One large or two small steam generators may be furnished, depending upon requirements.

100 **Diesel Engine** The model 12-567C engine, Fig. 1-2, is a V-12, two-cycle type, 8-1/2 inch bore and



12-567C Engine
Fig. 1-2

10 inch stroke, incorporating the advantages of low weight per horsepower, welded construction, unit fuel injection, and fully scavenging air system. It is rated at 1200 horsepower at 800 RPM. Idle speed is 275 RPM. Engine speeds are controlled by a model PG electro-hydraulic governor with rotary output shaft. Two of these engines are used in each unit of the E9 locomotive.

Scavenging air is supplied to the air boxes by two gear-driven Roots-type blowers. Inlet air enters the cylinders through ports in the lower part of the cylinder liners. Fuel is injected into the open-type combustion chamber by a GM unit injector, located centrally in each cylinder head, and actuated by a rocker arm. Exhaust gases leave through four poppet valves in the cylinder head. Exhaust valves are operated by rocker arms directly from camshafts mounted on top of each bank.

Water jackets are cast integrally with each cylinder liner. Water inlet to the liner and outlet from the cylinder head are by means of bolted jumper lines. Cylinder test valves are provided for checking for fluids in the combustion chamber before starting the engine. Removable round handhole covers on the air box and oil pan allow for inspection of the pistons and engine interior.

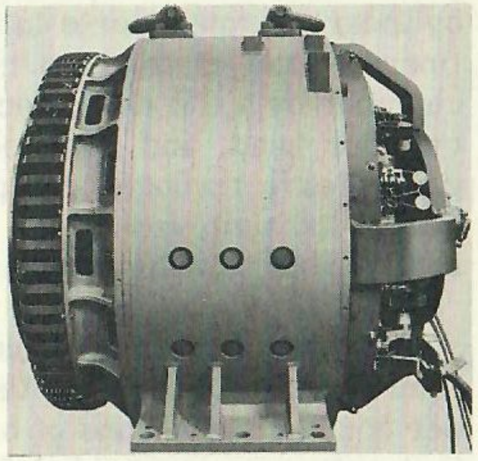
Two cooling water pumps are used, one supplying each cylinder bank. A scavenging oil pump forces lubricating oil through the oil cooler and filters. A dual pressure pump supplies independent oil pressure for engine lubrication and for piston-cooling jets. Fuel is circulated to the unit injectors by an electric motor-driven pump for each engine, and no high pressure fuel lines are used.

NOTE: In this manual, the word "engine" refers specifically to the Diesel engine; The word "locomotive" refers to a consist of one or more units.

101 **Main Generators** The main generator, Fig. 1-3, converts the engine power into electrical energy.

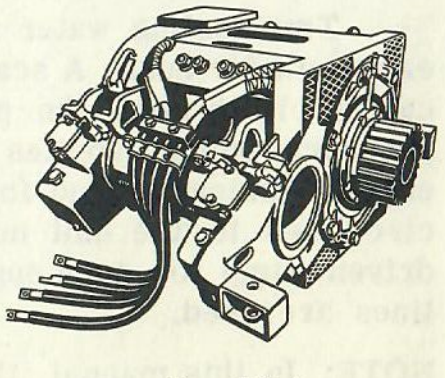
The D-15B main generator is a constant-kilowatt, variable-voltage machine which supplies direct current to the two traction motors of its power plant for locomotive propulsion.

102 **Alternators** The model D-16 alternator, Fig. 1-3, is built into the engine end of the main generator frame, but is not connected electrically to the main generator. This is a 3-phase alternating current generator which furnishes power only to drive the engine cooling and ventilating fans. The alternator field windings are protected by a circuit breaker. An alarm is provided for protection in case of AC failure. Use of this unique and reliable AC system eliminates the necessity for belts from the power plant to the cooling fans.

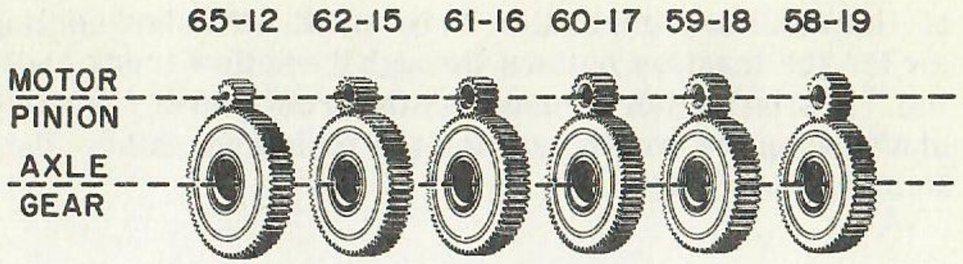


Main Generator
And Alternator
Fig. 1-3

103 **Traction Motors** The traction motors, Fig. 1-4, convert the main generator's electrical output into pulling power to move the locomotive. Two force-ventilated, series-wound, D-37 traction motors are mounted per truck. Each motor drives its pair of wheels through single reduction spur gears. The gear ratio is expressed by a double number, for instance, 52/25. Here the axle gear has 52 teeth and the motor gear has 25 teeth, Fig. 1-5.



Traction Motor
Fig. 1-4

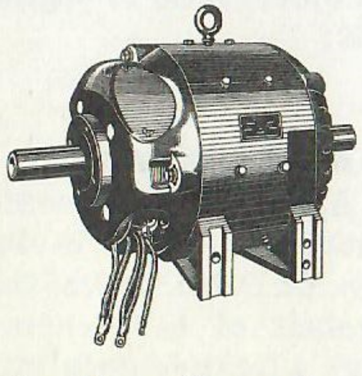


Gear Ratio Chart
Fig. 1-5

AUXILIARY EQUIPMENT

104 **Storage Battery** A 64-volt storage battery, divided into two groups of 16 cells each, is housed in battery boxes on opposite sides of the steam generator compartment inside the carbody. The battery supplies power to start the Diesel engine, for lights and for the low-voltage control systems. It is charged by the auxiliary generators of both engines. A main battery disconnect knife-switch is located in the left battery box. A receptacle is provided outside the carbody for charging the battery from an external power source.

105 **Auxiliary Generators** A 10-KW auxiliary generator, Fig. 1-6, is mounted on top of each main generator and is driven directly from the rear gear train of the engine through flexible couplings. These generators produce 74-volt direct-current to charge the battery and to supply the locomotive low-voltage systems. Ammeters showing auxiliary generator output, are mounted on each electrical control cabinet.

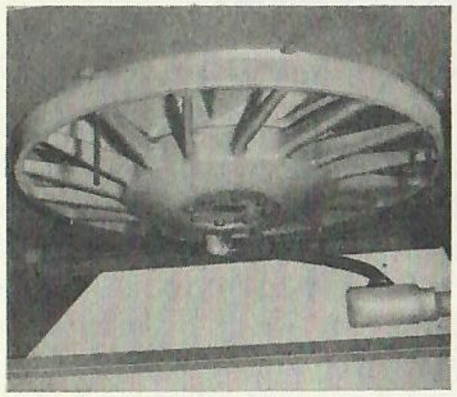


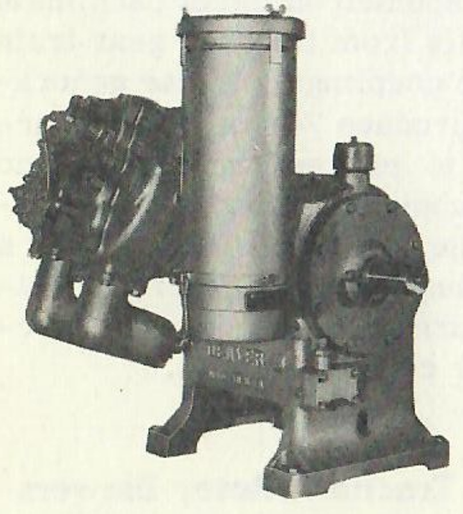
Auxiliary Generator
Fig. 1-6

106 **Traction Motor Blowers** A direct-driven, centrifugal blower mounted on the rear end

of the auxiliary generator drive shaft furnishes cooling air for the traction motors through the hollow truck casting. A similar fan mounted on the front end of the same shaft, supplies cooling air for the main generator. (See Item 2, Fig. 1-1).

107 **Radiator Cooling Fans** Three engine cooling fans, Fig. 1-7, are mounted in the radiator hatch above each engine. The fans are driven by individual 9-horsepower, 3-phase, squirrel cage induction motors having no brushes or commutator. The AC supply is provided by the alternator. An automatic thermostatic control turns each fan motor on or off and operates shutters as needed to maintain engine cooling water at the normal operating temperature. An engine room ventilating fan, identical to the cooling fans, is mounted in the roof hatch at each end of the engine room. Fan speed varies in direct ratio to engine speeds.


Cooling Fan
Fig. 1-7

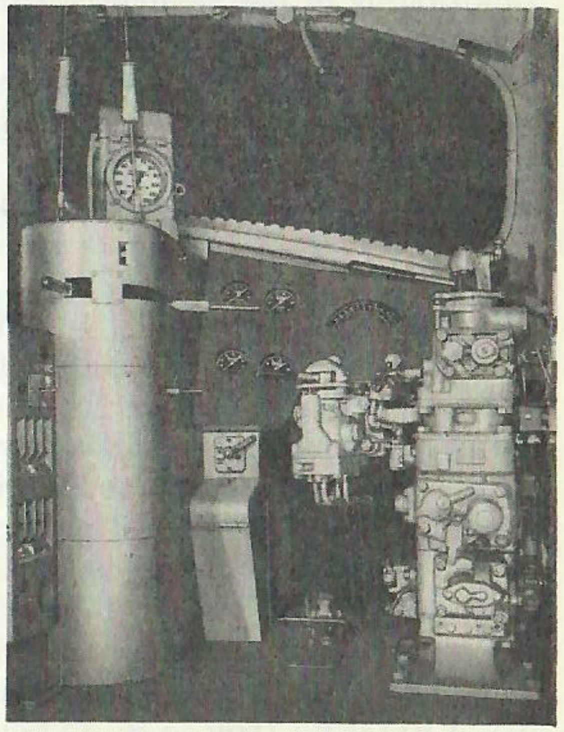

ABO Air Compressor
Fig. 1-8

108 **Air Compressor** A model ABO air compressor, Fig. 1-8, is directly driven from the crankshaft of each engine through a flexible coupling. The compressors are two-cylinder, two-stage, water-cooled type, rated at 112 CFM at 800 RPM. The lubricating oil supply may be checked by observing the sight glass. One air pressure governor controls the loading of both air compressors simultaneously.

109 **Fuel Pump** Separate electric motor-driven fuel supply pumps are used for each engine. The "Control and Fuel Pump" circuit breaker on the engineman's control stand, controls all of the fuel pumps in the locomotive. Individual fuel pumps are controlled by the "Fuel Pump" circuit breakers on each engine control panel. These circuit breakers must be ON at all times unless the engine is shut down.

OPERATING CONTROLS

Three levers and two brake handles, Fig. 1-9, control the entire operation of the locomotive. These are the throttle, selector and reverse levers located in the engineman's control stand, and the automatic brake and independent brake valves.


Operating Controls
Fig. 1-9

110 **Throttle Lever** The throttle lever controls the speed and horsepower output of all the engines and the train speed in normal operation. The position of the lever is shown in an illuminated indicator above the lever. The throttle

has ten positions — Stop, Idle, and Running Speeds 1 to 8. Stop is obtained by depressing the emergency stop button on the end of the lever and pushing the lever as far forward as it will go. This will stop all engines in the consist. Idle is as far forward as the lever will go without depressing the emergency stop button. Opening the throttle to Run 1 connects the power circuits. Further movement increases the engine speed 75 RPM per notch from 275 RPM in Idle and Run 1 to 800 RPM in Run 8. A mechanical escapement prevents the throttle from being opened more than one notch at a time, to prevent rough handling. The throttle may be closed completely with one motion in an emergency, but should be closed only one notch at a time in normal operation.

111 **Reverse Lever** The reverse lever has three positions: Forward, Neutral, and Reverse. The direction of locomotive movement is selected by the positioning of the reverse lever. With the reverse lever in Neutral, the locomotive will not develop power and will not move. The reverse lever should be moved only when the locomotive is standing still. It cannot be moved unless the throttle is in Idle. Removal of the reverse lever locks the operating control mechanism.

112 **Selector Lever** This lever is on the left side of the control stand. It has positions "No. 1" (Power) and OFF. On locomotives equipped with Dynamic brakes, it will also have a braking position "B." The locomotive is started with the selector lever in No. 1 position for power. The throttle lever can be opened only when the selector is in No. 1. The selector in the trailing "A" unit cab must be placed in OFF position.

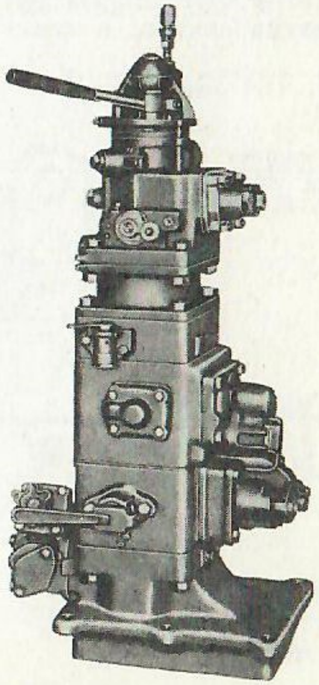
For dynamic braking, the selector is moved from No. 1 to OFF, then to B, to begin braking. As the lever is moved beyond "B," the braking effort is increased under control of the engineman.

113 **Mechanical Interlocks on the Controller** The levers on the control stand are interlocked so that:

1. The reverse lever can be operated only with the throttle in IDLE and the selector lever either in No. 1 or OFF.
2. The reverse lever can be removed from the control stand only with the selector lever in OFF and the throttle in IDLE.
3. Removal of the reverse lever locks the selector lever and throttle lever against any movement.
4. The selector can be moved only with the throttle in IDLE.
5. The selector can be moved to B only with the reverse lever in Forward or Reverse.
6. The throttle can be advanced above IDLE only with the selector lever in No. 1.
7. The throttle can be placed in STOP with any combination of reverse and selector lever positions.

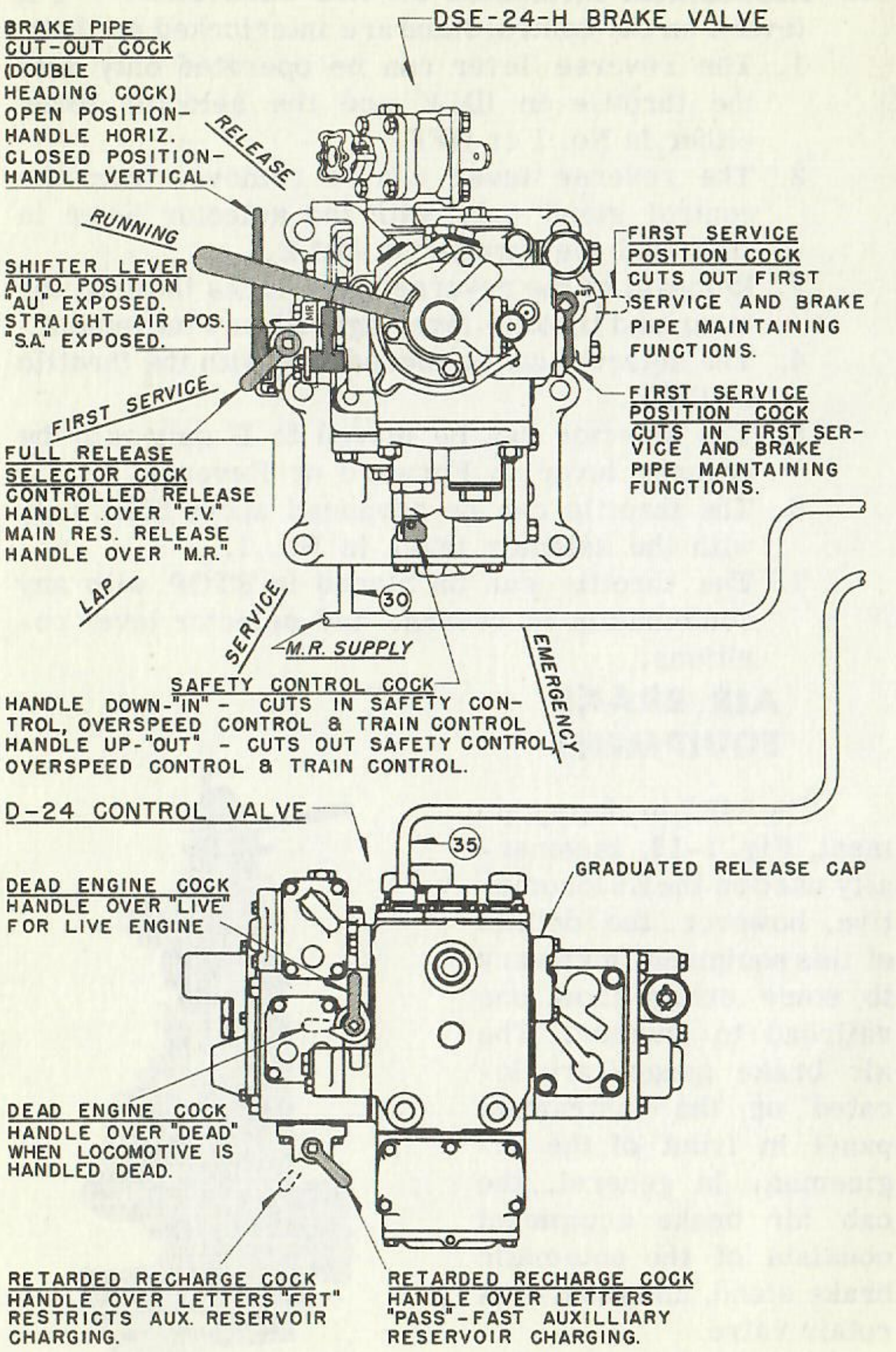
AIR BRAKE EQUIPMENT

The 24RL brake equipment, Fig. 1-10, is generally used on the E9 locomotive, however, the details of this equipment may vary to some extent from one railroad to another. The air brake gauges are located on the instrument panel in front of the engineman. In general, the cab air brake equipment consists of the automatic brake stand, and the K-2-A rotair valve.



24RL Brake
Fig. 1-10

114 **Automatic Brake**
The D-24 automatic brake valve, Fig. 1-11, has



BRAKE PIPE CUT-OUT COCK (DOUBLE HEADING COCK) OPEN POSITION- HANDLE HORIZ. CLOSED POSITION- HANDLE VERTICAL.

SHIFTER LEVER AUTO. POSITION "AU" EXPOSED. STRAIGHT AIR POS. "S.A." EXPOSED.

FULL RELEASE SELECTOR COCK CONTROLLED RELEASE HANDLE OVER "F.V." MAIN RES. RELEASE HANDLE OVER "M.R."

FIRST SERVICE POSITION COCK CUTS OUT FIRST SERVICE AND BRAKE PIPE MAINTAINING FUNCTIONS.

FIRST SERVICE POSITION COCK CUTS IN FIRST SERVICE AND BRAKE PIPE MAINTAINING FUNCTIONS.

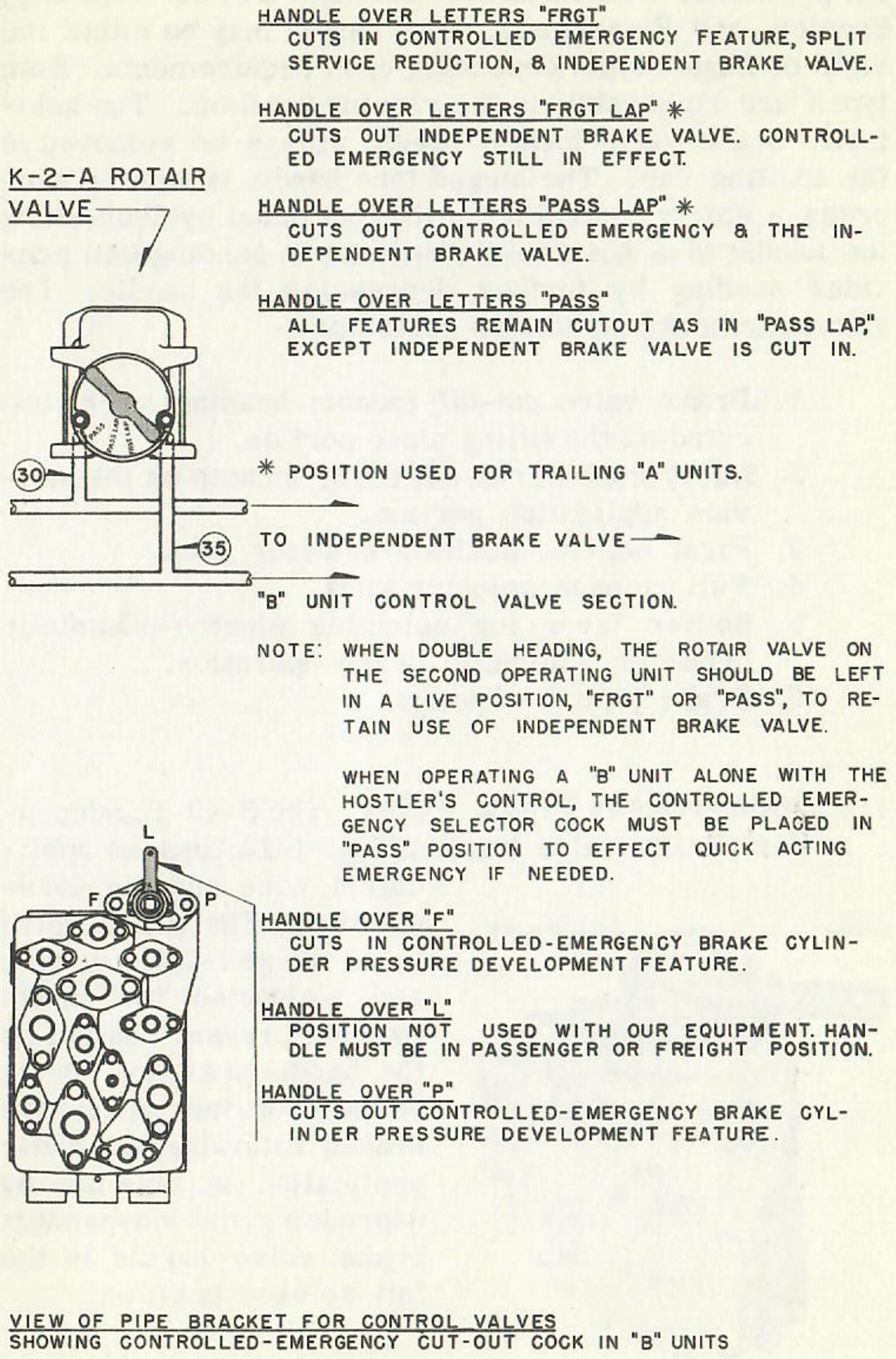
SAFETY CONTROL COCK HANDLE DOWN-"IN" - CUTS IN SAFETY CONTROL, OVERSPEED CONTROL & TRAIN CONTROL HANDLE UP-"OUT" - CUTS OUT SAFETY CONTROL, OVERSPEED CONTROL & TRAIN CONTROL.

DEAD ENGINE COCK HANDLE OVER "LIVE" FOR LIVE ENGINE

DEAD ENGINE COCK HANDLE OVER "DEAD" WHEN LOCOMOTIVE IS HANDLED DEAD.

RETARDED RECHARGE COCK HANDLE OVER LETTERS "FRT" RESTRICTS AUX. RESERVOIR CHARGING.

RETARDED RECHARGE COCK HANDLE OVER LETTERS "PASS"-FAST AUXILLIARY RESERVOIR CHARGING.



HANDLE OVER LETTERS "FRGT" CUTS IN CONTROLLED EMERGENCY FEATURE, SPLIT SERVICE REDUCTION, & INDEPENDENT BRAKE VALVE.

HANDLE OVER LETTERS "FRGT LAP" * CUTS OUT INDEPENDENT BRAKE VALVE. CONTROLLED EMERGENCY STILL IN EFFECT.

HANDLE OVER LETTERS "PASS LAP" * CUTS OUT CONTROLLED EMERGENCY & THE INDEPENDENT BRAKE VALVE.

HANDLE OVER LETTERS "PASS" ALL FEATURES REMAIN CUTOUT AS IN "PASS LAP," EXCEPT INDEPENDENT BRAKE VALVE IS CUT IN.

* POSITION USED FOR TRAILING "A" UNITS.

TO INDEPENDENT BRAKE VALVE

"B" UNIT CONTROL VALVE SECTION.

NOTE: WHEN DOUBLE HEADING, THE ROTAIR VALVE ON THE SECOND OPERATING UNIT SHOULD BE LEFT IN A LIVE POSITION, "FRGT" OR "PASS", TO RETAIN USE OF INDEPENDENT BRAKE VALVE.

WHEN OPERATING A "B" UNIT ALONE WITH THE HOSTLER'S CONTROL, THE CONTROLLED EMERGENCY SELECTOR COCK MUST BE PLACED IN "PASS" POSITION TO EFFECT QUICK ACTING EMERGENCY IF NEEDED.

HANDLE OVER "F" CUTS IN CONTROLLED-EMERGENCY BRAKE CYLINDER PRESSURE DEVELOPMENT FEATURE.

HANDLE OVER "L" POSITION NOT USED WITH OUR EQUIPMENT. HANDLE MUST BE IN PASSENGER OR FREIGHT POSITION.

HANDLE OVER "P" CUTS OUT CONTROLLED-EMERGENCY BRAKE CYLINDER PRESSURE DEVELOPMENT FEATURE.

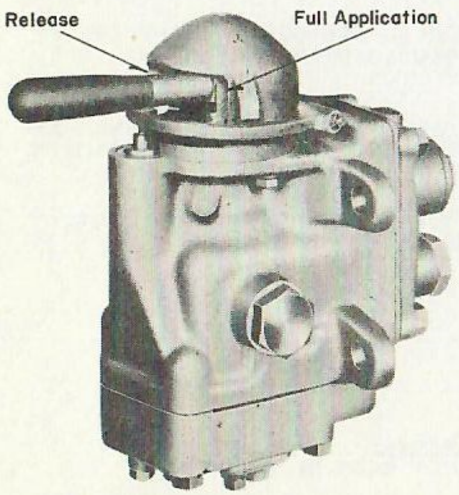
VIEW OF PIPE BRACKET FOR CONTROL VALVES SHOWING CONTROLLED-EMERGENCY CUT-OUT COCK IN "B" UNITS

24 RL Brake Cock Handle Positions
All Types Of Service
Fig. 1-11

six positions: Full Release, Running, First Service, Lap, Service, and Emergency. The handle may be either the rigid or hinged type, depending upon requirements. Both types are removable in the running position. The automatic brake valve handle should always be removed in the trailing cab. The hinged type handle is used to suppress a safety control from the foot pedal by depressing the handle to a horizontal position. A sanding bail provides sanding by further depressing the handle. The automatic brake stand also contains:

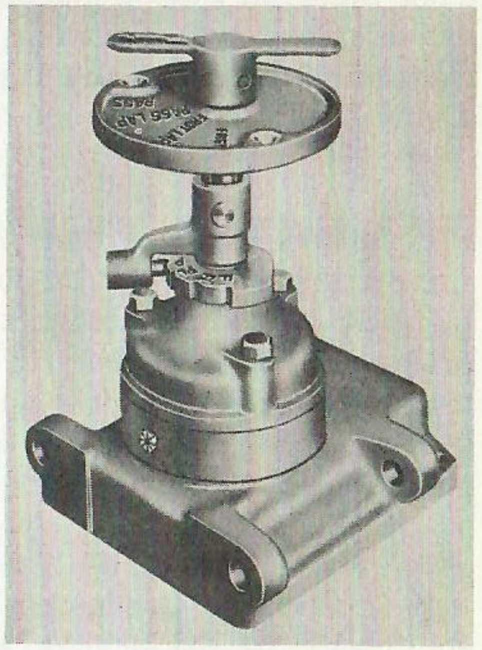
1. Brake valve cut-off (double-heading) cock, located on the filling piece portion.
2. Safety control cut-out cock, located on the service application portion.
3. First service position selector cock.
4. Full release selector cock.
5. Shifter lever for selecting electro-pneumatic brake or automatic brake operation.
6. Brake pipe feed valve.

115 **Independent Brake Valve** The S-40-F independent brake valve handle, Fig. 1-12, has an application zone and a release position. The brake valve is of the self-lapping type, and maintains the brake cylinder pressure as set by the handle position. Quick release of the locomotive brakes following automatic application is obtained by depressing the independent brake valve handle in the full release position.



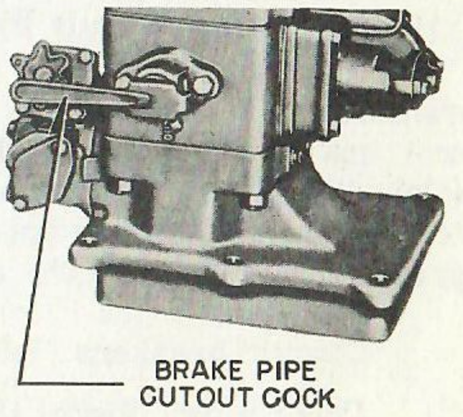
Independent Brake Valve
Fig. 1-12

116 **Rotair Valve** The K2A rotair valve, Fig. 1-13, is located under a hinged cover at the cab control stand, and has a dual function. It is used to cut the independent brake valve in or out, and also to provide controlled emergency and penalty applications. The rotair valve handle has four positions: Passenger, Passenger Lap, Freight Lap, and Freight. On passenger trains, short freight trains, or light locomotive, the rotair handle is placed in PASS. On long heavy trains, the handle is placed in FRT. In the trailing cab, the rotair is placed in the corresponding PASS LAP, or FRT LAP position. The LAP position renders the independent brake valve inoperative on that unit. The FRT position gives a controlled-emergency (slow brake cylinder pressure build-up) on the locomotive, and a split-reduction during a penalty application. PASS position gives a quick build-up in emergency, and a service reduction rate in penalty application.



K2A Rotair Valve
Fig. 1-13

117 **Brake Pipe Cut-Out Cock** The brake pipe cut-out cock (also known as the "double-heading cock"), Fig. 1-14, is located on the lower left side of the automatic brake stand. With the handle horizontal, the brake pipe



Brake Pipe Cut-Out Cock
Or Double-Heading Cock
Fig. 1-14

is "cut in," and the automatic brake valve will control the brakes. When the handle is vertical, the automatic brake valve is cut out. The handle is spring-loaded and self-locking. To move the handle, pull along its length, then rotate to desired position. The brake pipe cut-out cock must be closed (handle vertical) on all automatic brake valves except leading unit. Emergency application may be obtained at any time regardless of the position of the brake pipe cut-out cock.

118 **Safety Control Foot Pedal** (Item 16, Fig. 1-15)
The safety control foot pedal is located on the floor in front of the engineman's seat. The hinged automatic brake handle provides an alternate control when depressed. Either the foot pedal or the brake handle must be depressed at all times except when the locomotive is stopped and the locomotive brakes are applied with 30 pounds or more brake cylinder pressure. If both the pedal and brake handle are released at the same time, with locomotive brakes not applied, a penalty automatic application of the brakes will result.

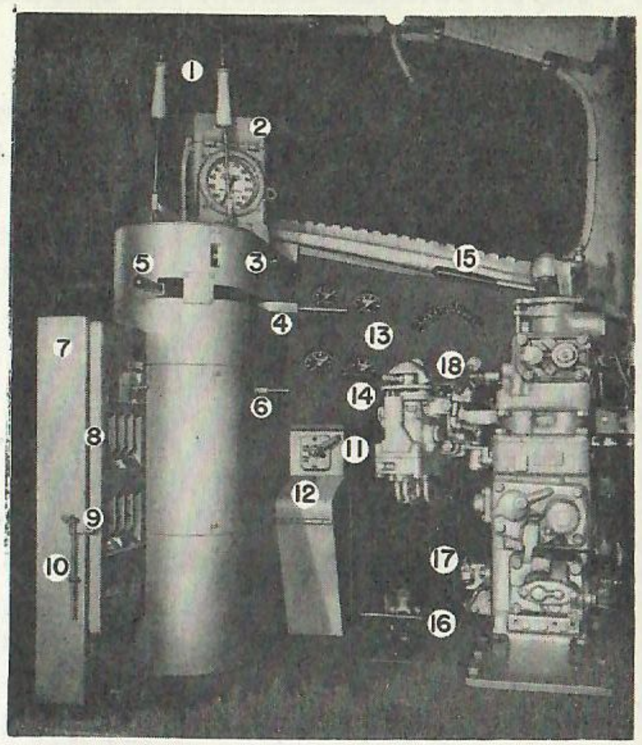
ENGINEMAN'S INSTRUMENT PANEL

119 **Operating Circuit Breakers** The engineman's controls, Fig. 1-15, contains circuit breaker type switches. Fig. 1-16 shows the circuit breakers for control and light circuits. The circuit breakers are ON (closed) when in the UP position. If a circuit breaker is overloaded and trips open, service is restored by first pressing switch fully OFF and then moving it to ON.

Circuit breakers, left to right:

Upper row: Signal light - Class lights
(Lights) Number lights - Gauge lights

Lower row: Control and Fuel Pump - Engine Run
(Controls) Generator Field - Automatic Sanding

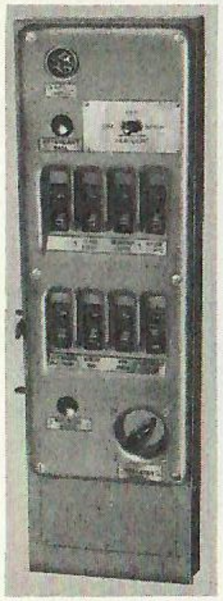


1. Horn Cords
2. Speed Recorder
3. Dimmer For Control Stand Gauge Lights
4. Throttle Lever
5. Selector Lever
6. Reverse Lever
7. Engineman's Control Panel
8. Circuit Breakers - Lights
9. Circuit Breakers - Controls
10. Pin For Locking Control Circuit Breakers OFF
11. Cab Ventilation Damper Handle
12. Rotair Valve - Under Hinged Cover
13. Engineman's Instrument Panel
14. Independent Brake Valve
15. Automatic Brake Valve
16. Safety Control Foot Pedal
17. Brake Pipe Cut-Out (Double-Heading) Cock
18. Bell Ringer Control

Engineman's Controls
Fig. 1-15

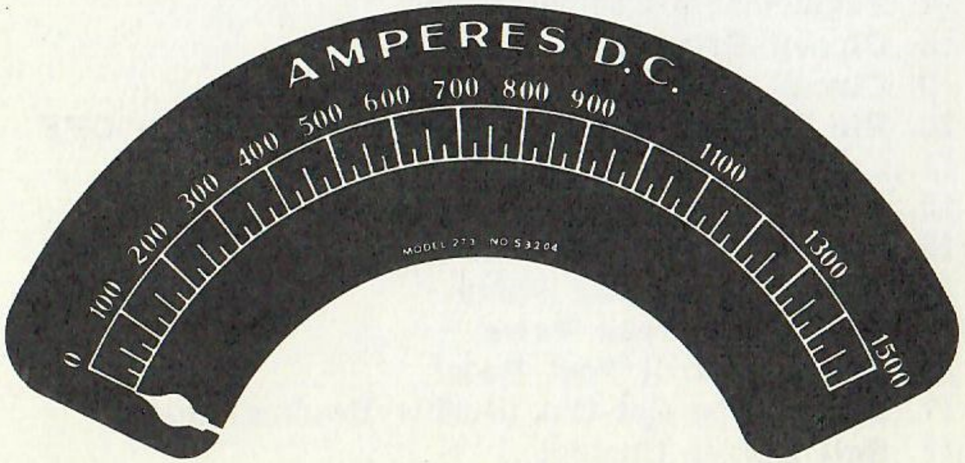
These control switches control the operation of all locomotive units in the consist.

The lower row may be locked OFF by inserting the locking pin in the hole provided in the panel. Additional circuit breakers are located on the electrical control cabinets in the locomotive cab and also in the steam generator compartment, at the rear of the unit.



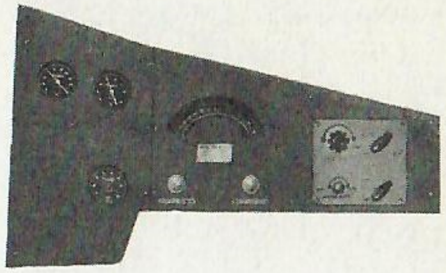
Circuit Breakers
Fig. 1-16

120 **Load Indicating Meter** This meter, Fig. 1-17, is an accurate guide to the load (PULL) on the locomotive. The dial of the meter is graduated in amperes, starting at 0 at the left and going to 1500 amperes at the extreme right of the scale. The meter is connected to the No. 2 traction motor. Since the power supply is the same to all motors, each motor receives the amperage shown on the meter. If the No. 1 engine is isolated, the load indicating meter will not operate as the No. 2 motor is located in the No. 1 truck, and the current is supplied from No. 1 generator.



Load Indicating Meter
Fig. 1-17

121 **Wheel Slip Light** This light is located on the engineman's control panel, Fig. 1-18. During the application of power, the flashing of this light indicates that a pair of wheels is slipping.



Engineman's Control Panel
Fig. 1-18

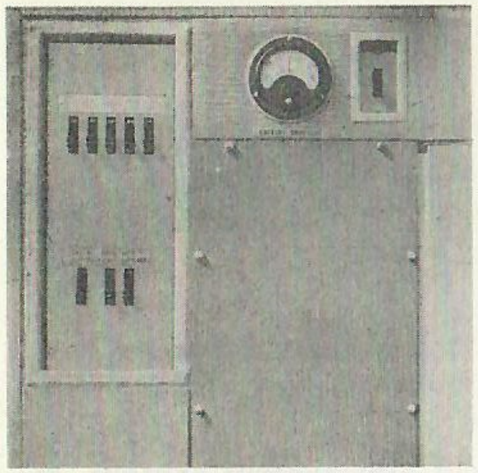
Power is automatically reduced on the slipping truck. With automatic sanding in use (Auto. Sanding circuit breaker in ON position, the wheel slip will generally be corrected immediately through the wheel slip control system, and the light will go out. The throttle need not be reduced unless continuous wheel slip occurs.

An additional indicating light is furnished as a dynamic brake warning light on locomotives so equipped. When motor cut-out switches are used, the wheel slip light will burn to indicate that a motor is cut out.

122 **PC Switch and PCS Open Light** The PC, or pneumatic control switch is often called the power cutoff switch. This is a normally closed electrical switch that is operated by the air brake system. During a safety control or emergency air brake application, this switch will trip open. When tripped open, the PC switch immediately reduces all engines to Run 1 speed. Fuel pumps will not stop on the E9 locomotive units. A white "PC Switch Open" indicating light, Fig. 1-18, on the engineman's instrument panel, will be lit whenever the PC switch is tripped.

The PC switch will automatically reset itself, provided that the throttle is returned to IDLE, and control of the brake is recovered. (See Section 2 for the method of recovering control of the brake).

123 **Headlight Control Switch** The sealed-beam headlight is controlled by a BRIGHT, DIM, OFF toggle switch on the engineman's control panel, Fig. 1-15, Item 7. A master headlight circuit breaker is located on the electrical control cabinet behind the fireman's seat, Fig. 1-19.



Circuit Breakers
(Fireman's Side)
Fig. 1-19

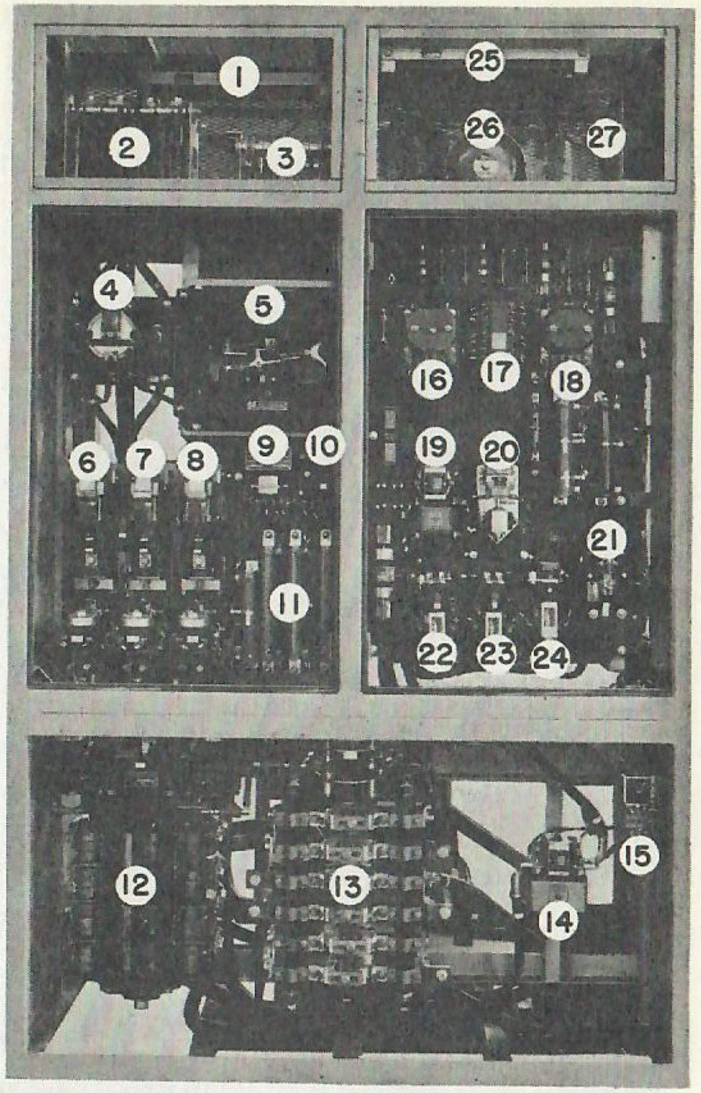
124 **Air Brake Gauges** These are standard air gauges mounted on the cab instrument panel, Fig. 1-18, and each is clearly labeled as to its function.

ELECTRICAL CONTROL CABINET

There is an electrical control cabinet provided for each power plant. The No. 1 electrical control cabinet, Fig. 1-20, is accessible from the engine-room, and the No. 2 electrical control cabinet is accessible from the steam generator room. Each cabinet contains both high and low voltage equipment for power plant operation, and also power contactors for connecting the traction motors to the main generator supply. Fig. 1-21A and B shows both the No. 1 and No. 2 high and low voltage panel.

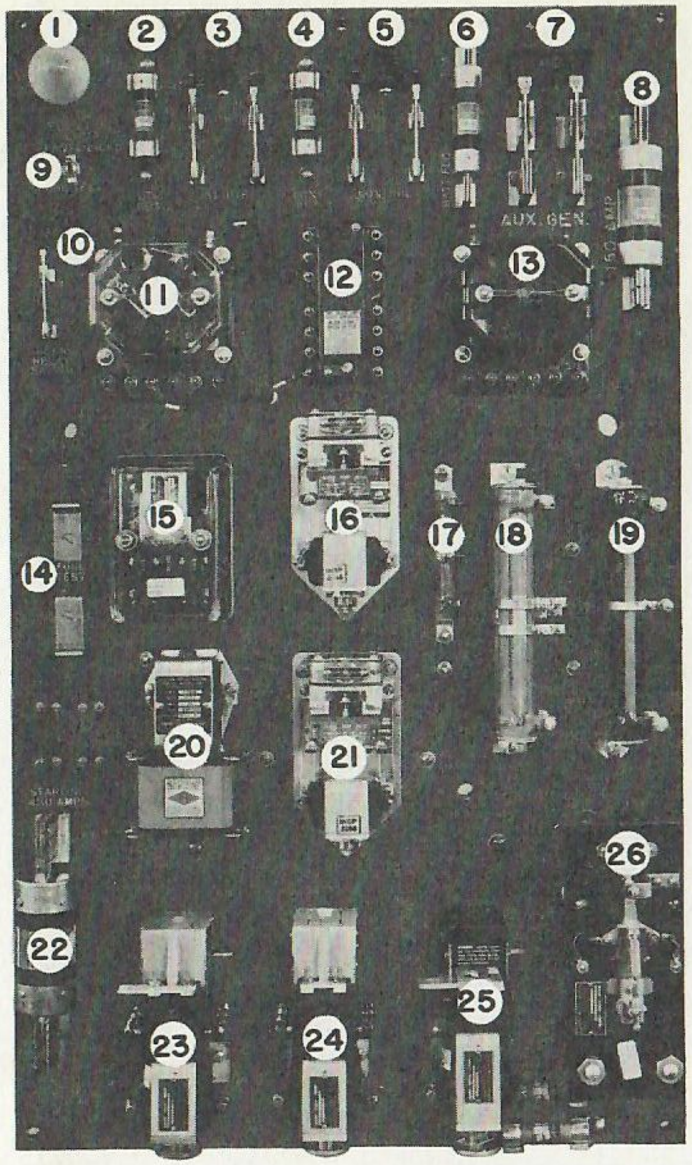
125 **Fuses** Each electrical control cabinet contains the following fuses:

400 amp. engine starting fuse



1. Alternator Field Resistor
2. Motor Field Shunt Resistor
3. Battery Charging Resistor
4. Shunting Contactor (SH)
5. Voltage Regulator
6. P2 Contactor
7. S12 Contactor
8. P1 Contactor
9. Dynamic Brake Regulator (DBR)
10. Brake Warning Relay (BWR)
11. Dynamic Brake Regulator Resistors
12. Reverser
13. Brake Transfer Switch (BKT)
14. Starting Contactor (GS)
15. Brake Relay (BR)
16. Ground Relay (GR)
17. Transition Relay (TR)
18. Forward Transition Relay (FTR)
19. Auxiliary Wheel Slip Relay (AWS)
20. Field Shunting Delay Relay (FSD)
21. Reverse Current Relay (RCR)
22. Battery Field Contactor (BF)
23. Shunt Field Contactor (SF)
24. Battery Charging Contactor (BD)
25. Generator Shunt Field Resistors
26. Alarm Bell
27. Wheel Slip Resistors

Electrical Control Cabinet
Fig. 1-20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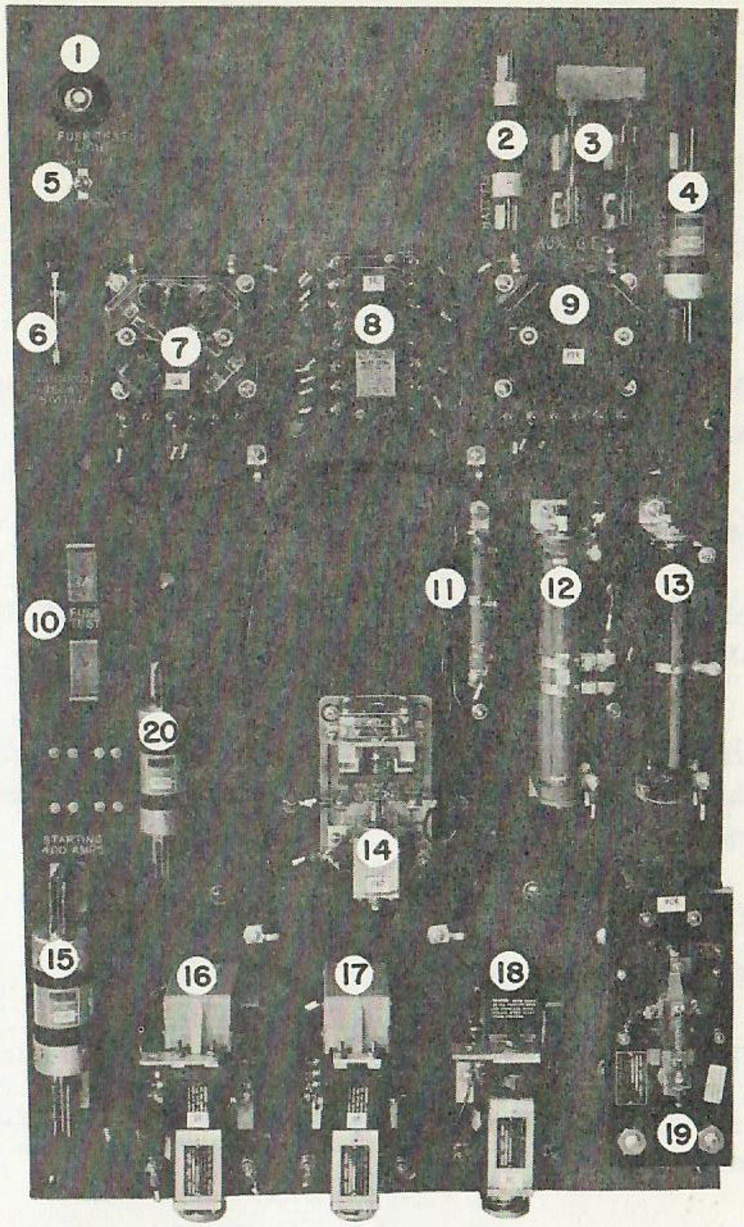
AUX. GEN.
150 AMP
STARTING 400 AMPS

1. Fuse Test Light
2. 60 Amp. Light Fuse
3. Light Switch
4. 60 Amp. Control Fuse
5. Control Switch
6. 70 Amp. Aux. Gen. Fuse
7. Auxiliary Generator Switch
8. 150 Amp. Aux. Gen. Fuse
9. Fuse Test Switch
10. Ground Relay Switch
11. Ground Relay
12. Transition Relay
13. Forward Transition Relay
14. Fuse Test Blocks
15. Pneumatic Control Relay
16. Time Delay Sanding Relay
17. Shunt Field Discharge Resistor
18. Transition Setting Resistors
19. Wheel Slip Resistors
20. Auxiliary Wheel Slip Relay
21. Field Shunting Delay Relay
22. 400 Amp. Starting Fuse
23. Battery Field Contactor
24. Shunt Field Contactor
25. Battery Charging Contactor
26. Reverse Current Relay

No. 1 High And Low Voltage Panel
Fig. 1-21A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FUSE TEST LIGHT
AUX. GEN.
STARTING 400 AMPS

1. Fuse Test Light
2. 70 Amp. Battery Field Fuse
3. Auxiliary Generator Switch
4. 150 Amp. Aux. Gen. Fuse
5. Fuse Test Switch
6. Ground Relay Switch
7. Ground Relay
8. Transition Relay
9. Forward Transition Relay
10. Fuse Test Blocks
11. Shunt Field Discharge Resistor
12. Transition Setting Resistors
13. Wheel Slip Resistors
14. Field Shunting Delay Relay
15. 400 Amp. Starting Fuse
16. Battery Field Contactor
17. Shunt Field Contactor
18. Battery Charging Contactor
19. Reverse Current Relay
20. Boiler Fuse

No. 2 High And Low Voltage Panel
Fig. 1-21B

150 amp. aux. gen. fuse

70 amp. battery field fuse

The No. 1 cabinet contains in addition:

60 amp. lights fuse

60 amp. control fuse

The No. 2 cabinet contains one steam generator fuse in addition to the above.

126 **Knife Switches**

Both the No. 1 cabinet and the No. 2 cabinet contains control and light knife switches.

127 **Circuit Breakers** Mounted on the outside of each cabinet for control of its power plant, the following circuit breakers:

30 amp. auxiliary generator field

30 amp. alternator field

These circuit breakers must be ON for operation.

In addition, the No. 1 cabinet has the following circuit breakers:

30 amp. auxiliary generator field

30 amp. alternator field

30 amp. signal light

15 amp. attendant call

15 amp. heater - defroster

30 amp. headlight (master)

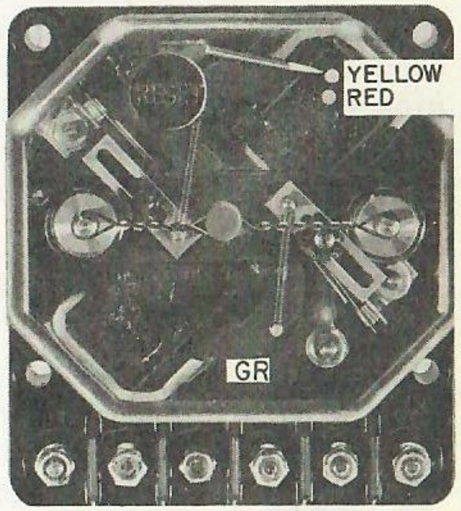
30 amp. lights

All these circuit breakers should be ON during normal operation.

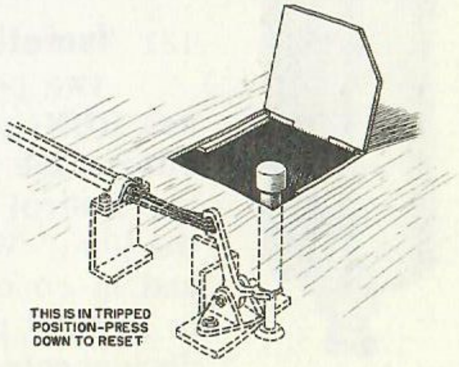
The signal light circuit breaker may be turned OFF in the trailing cab.

Each cabinet also has an ammeter which shows auxiliary generator output. This ammeter should show some charge at all times with the engine running.

128 **Ground Relay** The ground relays are located in the electric cabinets. The indicator, Fig. 1-22, points to yellow dot when set and to a red dot when tripped. When the relay is tripped the engine will not speed up when throttle is opened. The white "ground relay tripped" light will burn on the engine control panel. In No. 5 or 6 throttle position the engine will stop and the "no power" light will light. To reset, isolate the engine, reset the relay, and place engine on the line. If relay continues to trip, isolate the unit. The ground relay may be reset without opening the cabinet door by depressing the reset button mounted on the door panel.



Ground Relay
Fig. 1-22

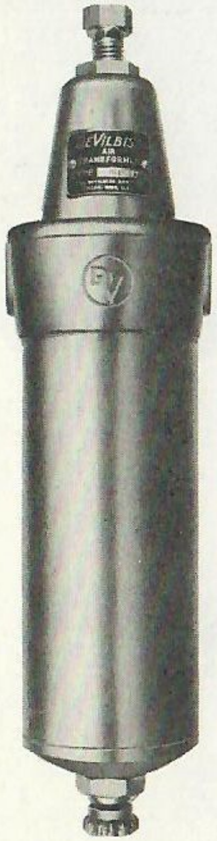


129 **Emergency Fuel Cut-Off Rings** An emergency fuel cut-off pull ring is located on the back

Emergency Fuel
Cut-Off Reset
Fig. 1-23

wall of the cab. Similar rings are mounted on each side of the locomotive, attached to the side skirt. Pulling a ring causes the quick-closing emergency fuel cut-off valve to trip, stopping the fuel supply to the engines and steam generator. The reset push rod is located between the engines, under a trapdoor in the floor, Fig. 1-23.

130 **Control Air Pressure Regulator** The control air for operating power contactors, reverser, and cam-switch is supplied from the main reservoir and reduced to 90 ± 3 pounds by the control air pressure regulator, Fig. 1-24. The pressure regulator is located behind the steps leading into the operating cab on the right side of the locomotive. The pressure is indicated on a gauge mounted on each of the electrical control cabinets.

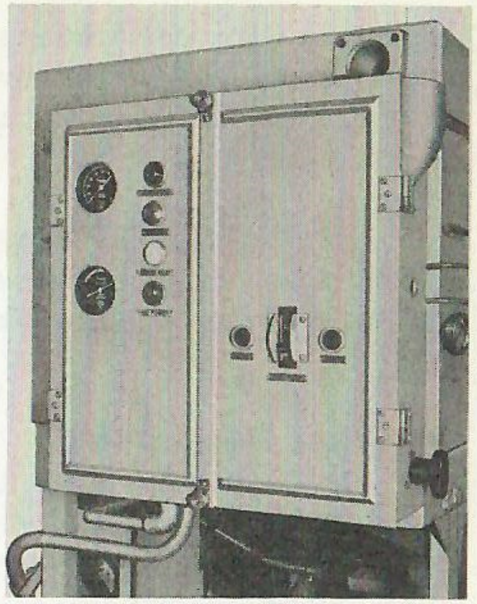


Control Air
Regulator
Fig. 1-24

ENGINE CONTROL PANEL

Each power plant has its own engine control panel, Fig. 1-25, on which are located the Isolation Switch, Start and Stop buttons, engine gauges, and alarm lights. The panel is mounted at the governor end of the engine.

131 **Isolation Switch** This switch has two positions, START (horizontal), and RUN (vertical. When in START position, the power plant is isolated from the control system and is said to be "off the line." When in RUN it is "on the line" and is connected to the control system. In START position, as the power plant is disconnected from throttle stand control, the engine speed is restricted to idle. Power contactors in the electrical control cabinet will not operate when control levers are moved and in dynamic braking, the unit will not exert retarding effort. "No Power" lights and alarm bells are inoperative. START and STOP buttons are effective only with isolation switch in START position.



Engine Control Panel
Fig. 1-25

The isolation switch must be firmly in the RUN position to obtain power from the unit. The switch should be opened and closed only with the engine at idle speed or stopped. Always use the manual layshaft lever to bring the engine to idle or stop when the locomotive is under power or in dynamic braking. If the isolation switch is in the START position do not place it in RUN while operating in dynamic braking.

132 **Engine Start and Stop Buttons** Isolation switch must be in START position to operate START and STOP buttons.

To start engine, be sure that the fuel pump is running, then press START button firmly until engine starts (not over 15 seconds).

To stop engine, press STOP button until engine stops completely.

133 **Alarm Lights** Four alarm-lights are mounted on each engine control panel, and an alarm bell is located in each electrical cabinet. The alarm lights indicate "Hot Engine," "Low Oil Pressure," "Ground Relay Tripped," or "No Power." A "Boiler Off" light is

located in the steam generator compartment. In case of alarm, from any of the above causes, bells will ring in all units, but the light will burn only on the unit affected.

134 **Lubricating Oil Gauges** Gauges on the engine control panel show engine lubricating oil pressure and engine lube oil pump suction.

135 **Fuel Pump Switch** This circuit breaker switch on the engine control panel in each unit, controls the individual fuel pump motor. The "Control and Fuel Pump" switch in the cab must also be ON for the fuel pump motor to run.

136 **Water Temperature Gauge** A gauge is mounted in each engine water tank near the engine control panel to indicate engine water inlet temperature. Normal operation is in the green area of the dial.

ENGINE ROOM

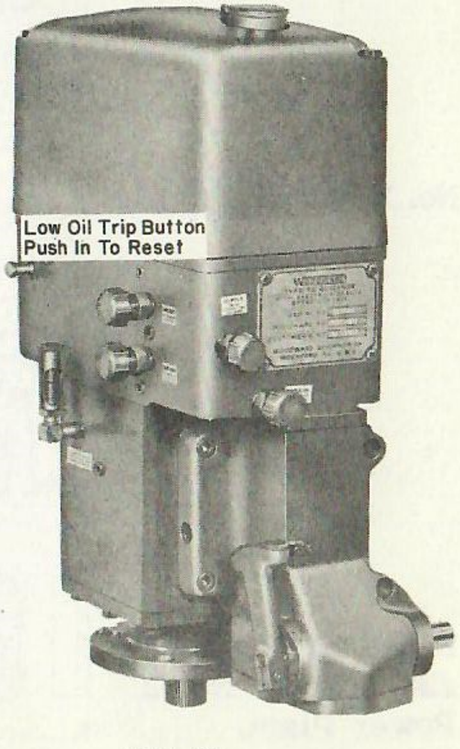
The two ends of the Diesel engine are designated FRONT and REAR. The accessory end, (governor and pumps), is the FRONT end. The generators and blowers are at the REAR end. In the locomotive, the fronts of the engines face each other, so that the No. 1 engine is "riding backward," and the No. 2 engine is "riding forward," Fig. 1-27.

137 **Engine Governor** The electro-hydraulic PG governor, Fig. 1-26, is mounted on the front end of the engine and controls the speed of the Diesel engine as directed by the position of the throttle at the engineman's control stand. The speed of the engine is controlled in steps of 75 RPM from 275 RPM at Idle to 800

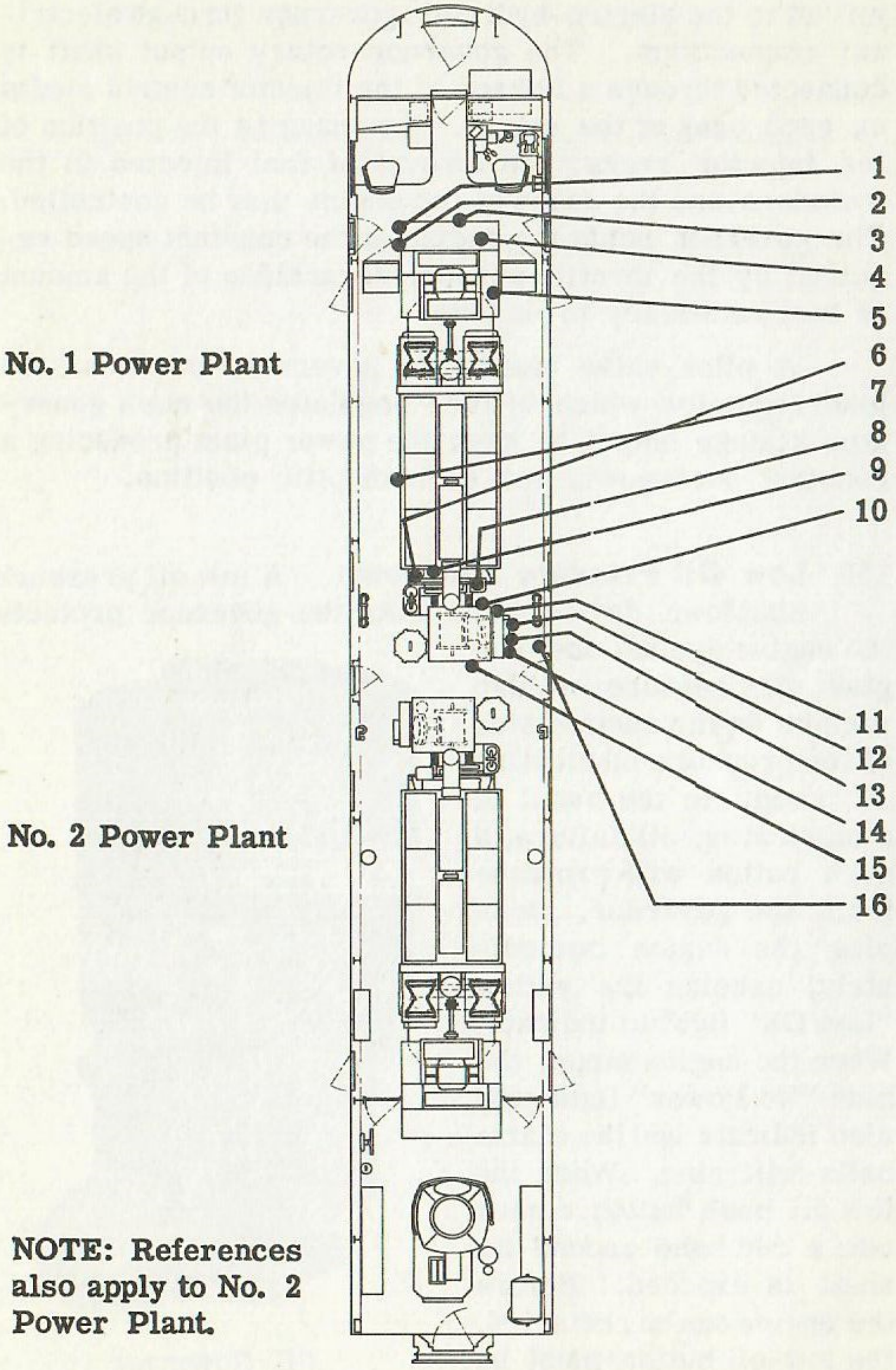
RPM in Run 8. The "orders" of the throttle are transmitted to the electro-hydraulic governor through electrical connections. The governor rotary output shaft is connected through a linkage to the injector control shafts on each bank of the engine. By changing the position of the injector racks, the amount of fuel injected to the cylinders and the speed of the engine may be controlled. The governor holds the engine at the constant speed required by the throttle setting, regardless of the amount of fuel necessary to do this.

A pilot valve inside the governor, positions the load regulator which in turn regulates the main generator voltage output to keep the power plant producing a constant horsepower for each throttle position.

138 **Low Oil Pressure Shutdown** A low oil pressure shutdown device built into the governor protects the engine against low engine oil pressure or high vacuum on the suction side of the pressure lubricating oil pump. In the event of a lubricating oil failure, a push button will protrude from the governor, stopping the engine immediately, causing the yellow "Low Oil" light to indicate. When the engine stops, the blue "No Power" light will also indicate and the alarm bells will ring. When the low oil push button comes out, a red band around its shaft is exposed. Before the engine can be restarted, the low-oil button must be pushed IN. The low-oil



PG Governor
Fig. 1-26



NOTE: References also apply to No. 2 Power Plant.

ENGINE ROOM CHECK CHART

	Item	Indication Should Be	Refer To Art. No.
1	Circuit Breakers	On	513-119
2	Aux. Gen. Ammeter	0 to 20	514-313
3	Ground Relay	Yellow Dot	223-128
4	Starting Contactor	Open	509
5	Control Air Pressure	90 3 Lbs.	305-130
6	Fuel Flow	5# Sight Glass Full	411-303
7	Engine Lube Oil	Full - or Near	300-405
8	Gov. Lube Oil Trip	In (No Red Band)	138
9	Engine Overspeed Trip	Set	300-302
10	Eng. Water Temp.	150° to 180°	300-401
11	Isolation Sw.	Run	202
12	Fuel Pump Switch	On	505-135
13	Lube Oil Pressure	6 psi or above	300
14	Lube Oil Suction	Green Area	300
15	Boiler Water Gauge	Full - or Near	300-600
16	Load Regulator		139

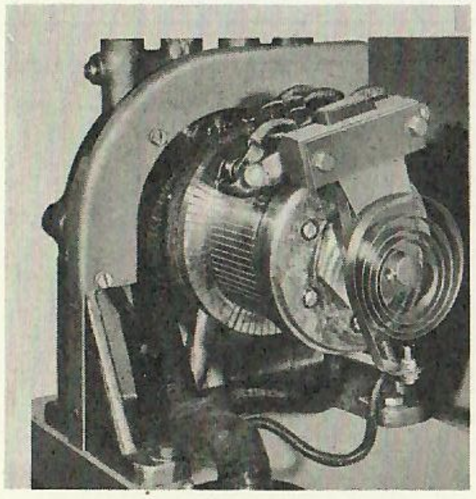
Location Of Equipment
Fig. 1-27

shutdown will not trip if the engine is stopped by means other than low lube oil pressure.

When the engine is started and run at idling speed, the governor will again stop the engine after about 40 seconds if the low-oil pressure condition continues. If an attempt is made to run the engine above idling speed during the delay period, the governor will immediately stop the engine if the oil pressure and suction are not normal. This governor gives positive low-oil protection, regardless of the position of the Isolation Switch.

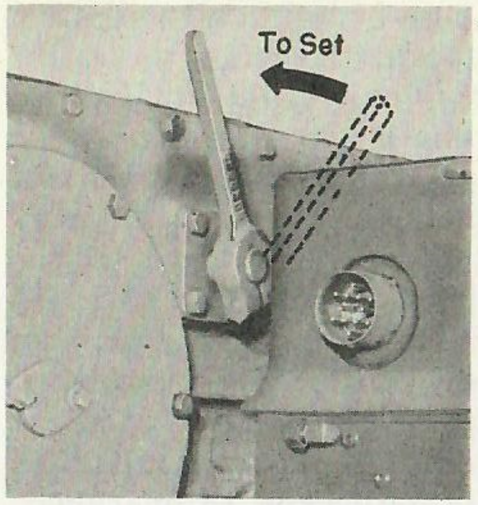
139 **Load Regulator** The load regulator, Fig. 1-28, is located below the engine lube oil cooling tank. Movement of the load regulator is controlled by the engine lubricating oil directed by the load regulator pilot valve and a dump valve (ORS) in the engine governor. The function of the load regulator is to automatically vary the battery field strength in the main generator, thereby maintaining a power output corresponding to a definite rate of fuel consumption as determined by the position of the throttle. See Article 137, Engine Governor,

The load regulator is in minimum field position when the brush arm, as viewed through the window, is in the 4 o'clock position. Maximum field excitation is obtained with the brush arm in the 8 o'clock position. When all engines are producing equal amounts of power, their load regulators will be in approximately the same relative position.



Load Regulator
Fig. 1-28

140 **Engine Overspeed Trip** If the engine speed should exceed approximately 910 RPM, an overspeed device, Fig. 1-29, located on the front end of the engine will trip and stop the engine by preventing the injectors from injecting fuel into the cylinders. The alarm bell and purple "no power" light will come on if the engine is stopped in this manner while "on the line." The overspeed trip must be latched in the SET position before the engine can be restarted.



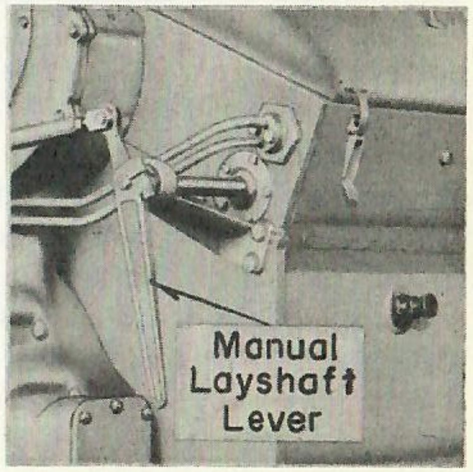
Engine Overspeed Trip
Fig. 1-29

141 **Layshaft Manual Control Lever** The layshaft manual control lever, Fig. 1-30, is attached to the end of the injector layshaft, at the left front corner of the engine and is accessible when standing at the engine control panel. It may be used to shut the engine down manually at any time.

142 **Cylinder Test Valves** Each cylinder is equipped with a test valve for testing for liquid accumulation in the cylinder before starting the engine. The test valves must be kept tightly closed when engine is running.

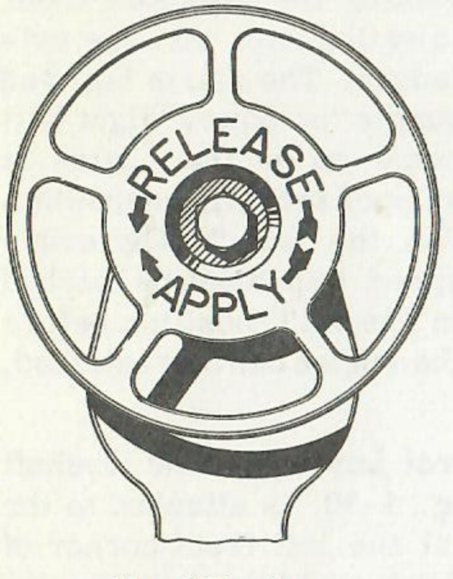
MISCELLANEOUS EQUIPMENT

143 **Speed Recorder Locomotive Overspeed Control** The speed recorder, located in



Manual Layshaft Lever
Fig. 1-30

front of the cab control stand, is a hydraulically operated speed indicator with a speed recording tape and an odometer. It is driven from the idler axle of the No. 1 truck, through a flexible cable. It contains a maximum speed protective device which will initiate a penalty full service application of the brakes and trip the PC switch when the maximum speed setting is exceeded. On some railroads, instead of a full service application of the brakes, an emergency application is initiated.



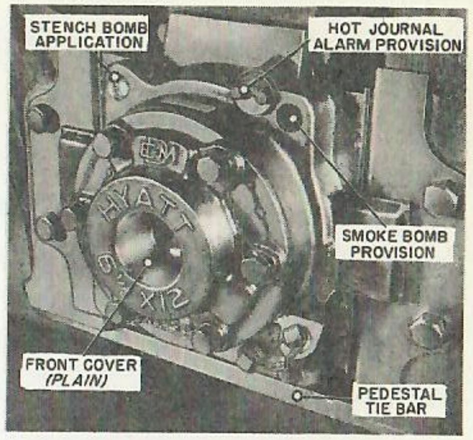
Hand Brake
Fig. 1-31

144 **Hand Brake** The hand brake, Fig. 1-31, is located in the engine compartment, on the left side of the locomotive. To set the brakes, the brake wheel is turned to the right. To release brake, turn to left. Whenever anyone is working around the locomotive trucks, the hand brakes should be applied. Before moving the locomotive, be sure the brakes are completely released.

145 **Sanding Valve** On locomotives equipped with the hinged automatic brake valve handle, sanding is accomplished by depressing the lever firmly. This movement operates the sanding bail which opens a port to supply air to the sanding equipment. On locomotives having a rigid handle on the automatic brake valve, an independent sanding valve is installed on the cab side panel. This lever is operated by pushing the lever forward or backward until it latches.

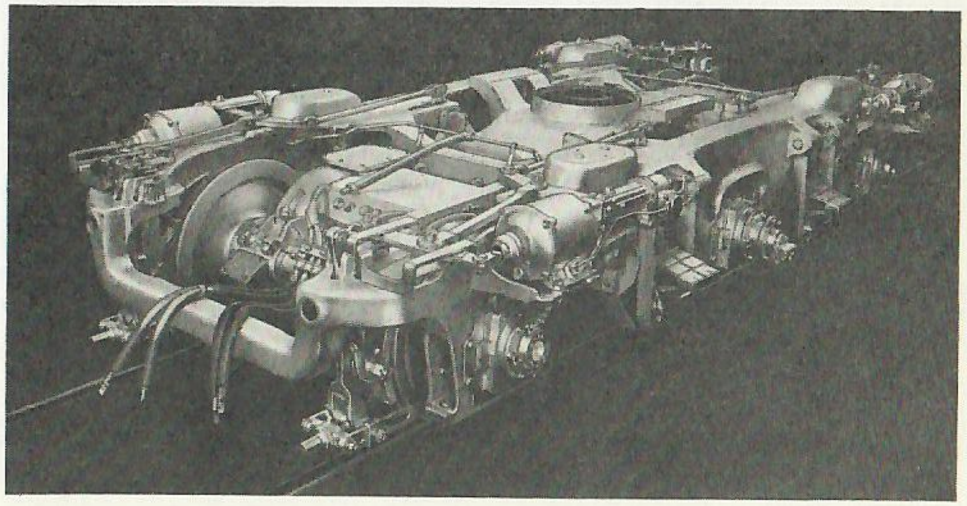
146 **Trucks** Two six-wheel, two-motor trucks give stable high-speed operation. The front and

rear wheels of each truck are powered, while the center wheels are idlers to aid in weight distribution. Clasp type brakes are used. The axles are all equipped with Hyatt roller bearing journal boxes, Fig. 1-32, incorporating a rubber-cushioned lateral thrust block. A stench bomb on each journal box will release a pungent odor if the temperature inside the journal box exceeds 220° F. See Fig. 1-33.



Hyatt Journal Box
Fig. 1-32

147 **Classification Lights** A permanently fixed, clear bull's-eye is provided on each side of the nose. Inside the nose and behind each bull's-eye, a small compartment contains the classification light bulb and colored lenses. Red and green lenses are provided which can be moved into a position between the bulb and the bull's-eye. To accomplish this, the locking pin is removed, the desired lens swung into place and the lock-



6-Wheel Truck
Fig. 1-33

ing pin replaced. The lenses are accessible from the inside of the nose section through hinged doors in the compartments. When both red and green lenses are out of position the permanent bull's-eye lens will show a white light, thus making three colors available.

148 **Number Box Lights** The boxes are located on each side of the nose, under the classification lights.

149 **Horn Valves** The horns are operated by air valves which are operated by pull-cords, above the control stand. The horn shut-off valve is located in front of the No. 2 main reservoir.

150 **Locomotive Bell** The locomotive signal bell is under the locomotive floor behind the pilot on the left side. It is operated by an air valve located at the engineman's station.

151 **Windshield Wipers** The windshield wipers are controlled by valves, one of which is located on the engineman's instrument panel, and one on the panel on the fireman's side of the cab. These wipers operate independently of each other. The wipers should not be run on a dry window as dirt on the glass or blade will scratch the glass, and wear out the rubber blade.

152 **Cab Heater** A cab heater is located on each side of the cab. Steam from the steam line passes through the heaters and motor-driven fans provide air circulation. The output of each heater can be varied by use of the cab heater switches. The switches have four positions: "OFF," 1, 2, 3, which provide three different motor speeds, No. 1 being the highest speed and No. 3 the slowest.

SECTION 2

OPERATION

Successful road operation depends upon the proficiency of the operating crew, as well as the maintenance forces.

A "pre-service" check should be made by the engine crew on boarding the locomotive. It is strongly recommended that the items listed be checked thoroughly and without omission. Careless inspection may result in road failures and cause train delays.

BASIC INFORMATION

200 When Boarding The Locomotive

A. Inspect exterior of locomotive and running gear for:

1. Fuel oil, lube oil, water or air leaking from the locomotive.
2. Loose or dragging parts.
3. Proper positioning of air hoses and angle cocks.
4. Observe brake cylinder piston travel.
5. Condition of brake shoes.
6. Adequate fuel supply showing in fuel tank full length sight glass.
7. Proper connections of air hoses and jumper cables. (Multiple Unit Operation.)

B. Engine Room Inspection

(If the engine is stopped, see Art. 201-202.)

With the engines running, check the following engine room items:

1. Engine lube oil dipsticks. (Between Full and Low marks.)
2. Oil in engine governors. (Oil showing in the sight glass.)
3. Engine cooling water supply. (At Running level in sight glass.)
4. Engine lube oil pressure. (Approximately 25 p.s.i. at Idle.)
5. Air compressor lube oil level to full mark in sight glass at all engine speeds.
6. Fuel return sight glass. (Glass next to engine FULL.)
7. Auxiliary Generator ammeters. (All showing CHARGE.)
8. All Isolation switches in RUN position.
9. No alarm lights burning.
10. Auxiliary Generator, Auxiliary Generator Field, Alternator Field circuit breakers ON at all electrical cabinets.
11. All fuses in place. All knife switches closed.
12. Drain condensate from air system.
13. Inspect for fuel, oil, water leaks, and unusual noises.
14. In "B" units, the "Controlled Emergency Cock" on the D-24 control valve should be set the same as the Rotair valve in the operating cab. ("PASS or FRT")
15. Release all hand brakes.

C. Operating Cab

To prepare for moving the locomotive, the controls should be in the following positions in the operating cab:

1. Automatic and Independent brake handles in place.
2. Brake pipe cutout (double-heading) cock open. (Handle horizontal.)
3. Rotair valve in PASS or FRT position, according to service.
4. PC Switch set. (PCS Open light out.)
5. Reverse lever inserted.
6. Selector lever in No. 1 position. To move lever, lift as high as it will go, and press firmly in the direction desired. Maintain this side pressure and lower the lever; it will slip into position.
7. Control-and-Fuel Pump, Engine Run, Automatic Sanding switches on Engineman's control panel ON. As a safety precaution, the Generator Field switch is left OFF until ready to move.
8. All circuit breakers on panel behind Fireman's seat ON.
9. Electro-pneumatic brake power switch in electrical cabinet ON.
10. Dynamic Brake Unit Selector switch set to equal the number of units in locomotive, if used.
11. See that brake cylinder pistons actually apply and release.

CAUTION: Brakes may be cut out at trucks and cab air gauges will still indicate normal operation.

D. Non-operating Cab.

In the non-operating cab, the controls should be in the following positions:

1. Selector lever in OFF, throttle in IDLE, reverse lever removed from control stand.
2. Brake pipe cutout (double-heading) cock closed. (Handle vertical.)
3. Rotair valve set in PASS LAP or FRT LAP according to Rotair position in lead cab.
4. Automatic and Independent brake handles removed.
5. All circuit breakers on Engineman's panel OFF and locking pin inserted to lock lower row.
6. Signal Light circuit breaker OFF at panel behind Fireman's seat. All other circuit breakers on the panel ON.

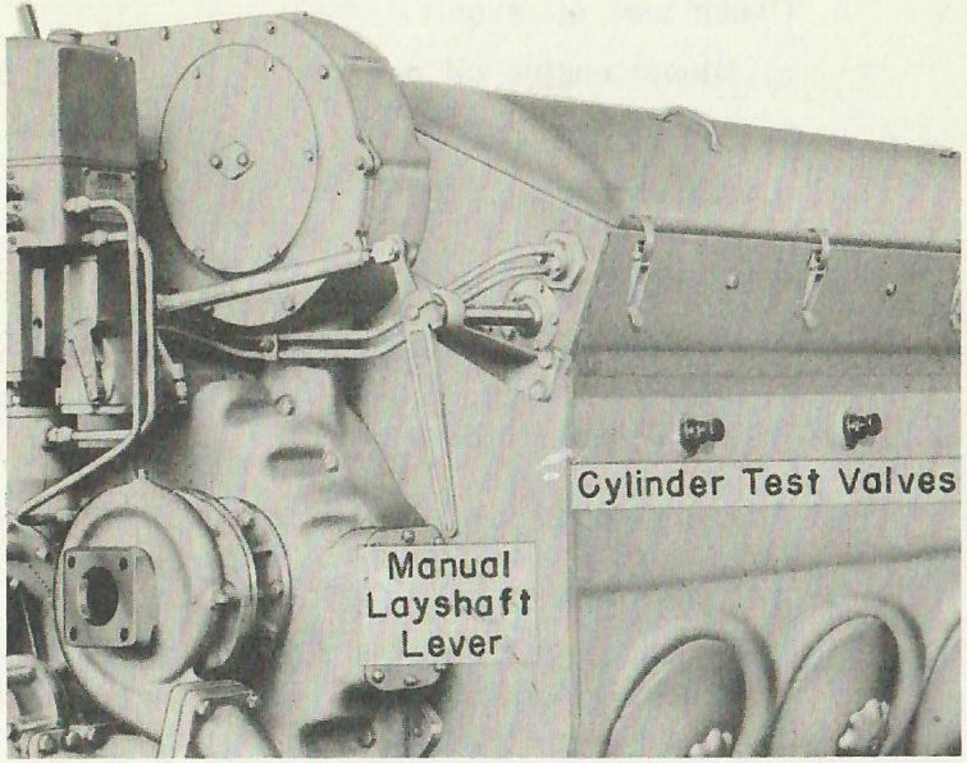
201 **Precautions Before Starting Engine** The following operations should be performed when an engine is to be started after a layover. If the engine has been stopped for a short period of time, or less than the time limit set by the mechanical officials of the individual railroad, Item 10 may be omitted.

1. If locomotive is stopped, place the independent brake in full application position.
2. Check position of all valves:
    a. Cooling system.
    b. Lube oil system.
    c. Air system.
3. Remove reverse lever from the controller.
4. Check engine cooling water level.

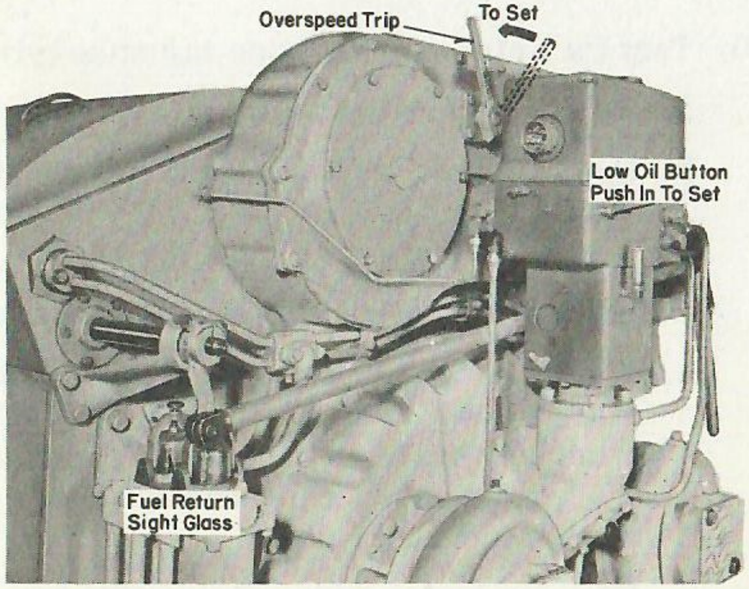
5. Check lube oil supply:
    a. Diesel engine oil pan.
    b. Engine governor.
    c. Air compressor.
6. Place the isolation switch in the start position.
7. Close all knife switches and circuit breakers in the electrical cabinets and check to see that all fusetrons are in place.
8. Place "Control and Fuel Pump" and "Engine Run" circuit breakers at the Engineman's control station in the ON position.

    Note: When operating the E9 as a lead unit in multiple with older type units not equipped with an "Engine Run" circuit breaker, the "Engine Run" circuit breaker on the lead E9 must be ON to start and keep the fuel pumps of the trailing older type units running.

10. Test for water accumulation in engine cylinders:
    a. Remove 400 ampere starting fuse.
    b. Open engine cylinder test valves (3 full turns), Fig. 2-1.
    c. Rotate engine at least one complete revolution by use of the engine turning jack.
    d. Watch the cylinder test valves while the engine is being rotated. If water is discharged from any test valve, do not attempt to start the engine until the cause has been determined and corrected.
    e. Close cylinder test valves with special pin wrench.
    f. Replace 400 ampere starting fuse.



Cylinder Test Valves
Fig. 2-1



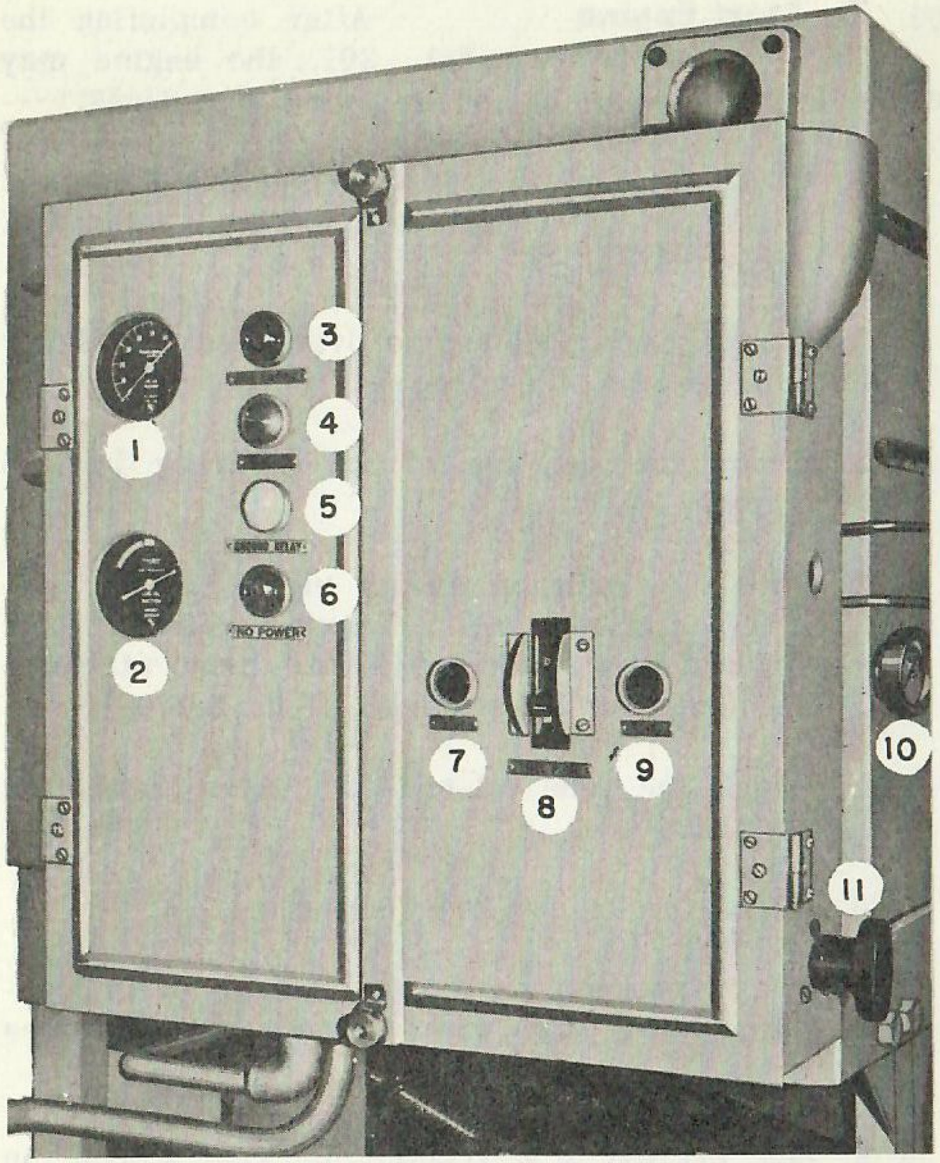
Overspeed Trip And Fuel Flow Chart
Fig. 2-2

202 **To Start Engine** After completing the items mentioned in Art. 201, the engine may be started by performing the following operations:

1. Check for fuel flow through "return fuel sight glass" on fuel filter mounted on front end of engine, Fig. 2-2.
2. Check position of engine overspeed trip lever at front end of engine.
3. Check the position of the governor low oil button.
4. With the isolation switch in the "start" position, firmly press the engine "START" button and hold it in until the engine starts to run (not over 15 seconds), Fig. 2-3.
5. Check the lube oil pressure after engine has started.
6. Check for ground relay action.
7. Idle the engine in the isolated or START position until the water temperature becomes normal.
8. See Section 3 if trouble is experienced in starting the engines.

203 **Placing An Engine On The Line** Before the engineman can control the speed of the engine with the throttle lever, the engine must be placed "on the line," and the "Engine Run" circuit breaker must be in the ON position.

1. After the oil pressure and engine temperature have raised to normal, the engine is placed

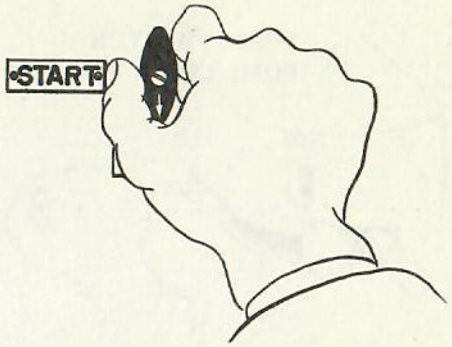


1. Lube Oil Pressure
2. Lube Oil Suction
3. Red Light — Hot Engine
4. Yellow Light — Low Oil or High Suction
5. White Light — Ground Relay
6. Blue Light — No Power
7. Engine Stop Button
8. Fuel Pump Switch
9. Engine Start Button
10. Cooling Water Inlet Temperature Gauge
11. Isolation Switch

Engine Control And Instrument Panel
Fig. 2-3

"on the line" by moving the isolation switch to the RUN or vertical position, Fig. 2-4.

2. DO NOT place engine on the line when the locomotive is being operated in dynamic braking.

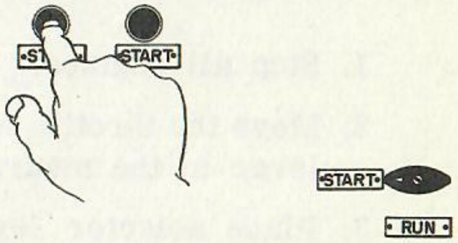


Placing Engine On the Line
Fig. 2-4

204 To Stop Engine

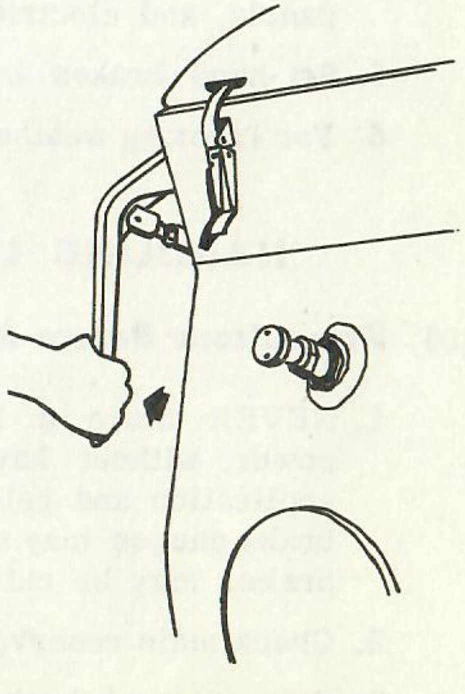
There are three ways of stopping an engine. These may be designated as Normal, Under Power, and Emergency.

1. Normal - Applies when the locomotive is standing still. Place isolation switch in the START position and press in on the STOP button on the engine control panel until the engine stops, Fig. 2-5.



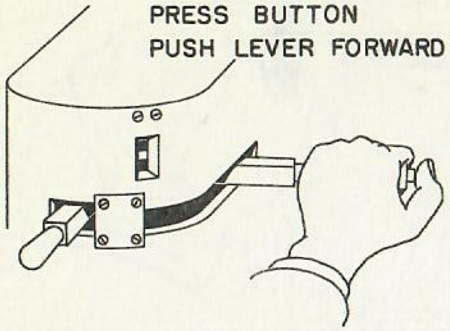
Stopping Engine
Fig. 2-5

2. Under Power or Dynamic Braking - Pull the engine layshaft closed until the engine stops, Fig. 2-6. Then move the isolation switch to the START position and turn off the fuel pump switch at the engine control panel.



Stopping Engine
Fig. 2-6

3. Emergency - All engines "on the line" are



Stopping Engine
Fig. 2-7

simultaneously stopped by depressing the emergency stop button on the end of the throttle lever and pushing the throttle as far closed as possible to the STOP position, Fig. 2-7.

205 Securing Locomotive For Layover

1. Stop all engines.
2. Move the throttle to idle and place the reverse lever in the neutral position.
3. Place selector lever in the OFF position and remove the reverse lever from the controller.
4. Turn OFF all switches and circuit breakers at the Engineman's control stand, engine control panels, and electrical control cabinets.
5. Set hand brakes and block the wheels.
6. For freezing weather precautions see Art. 219.

HANDLING LOCOMOTIVE

206 Precautions Before Moving Locomotive

1. NEVER move a locomotive, under its own power, without having first observed proper application and release of the brakes. Cab air brake gauges may show normal operation while brakes may be cut out at trucks.
2. Check main reservoir and control air pressure.
3. Release hand brakes.
4. Engine cooling water should be 120° or more.

207 Handling Light Locomotives

With the engines placed on the line and cab preparations completed the locomotive is handled as follows:

1. Move Engine Run switch to ON.
2. Move Generator Field switch to ON.
3. Insert and move the reverse lever to the desired position. (This lever is to be moved ONLY when the locomotive is standing still.)
4. Place the selector lever in the No. 1 position.
5. Depress safety control foot pedal (if used).
6. Release the air brakes.
7. When running light, open the throttle a notch at a time.

208 Coupling To Train

1. Make certain coupler cover door is OPEN on rear "A" unit pilot.
2. Locomotive must not be moved with air hoses hanging free on nose of "A" units.
3. In backing onto a train it may be desirable to use the attendant's call in rear "A" unit or train signal whistle valves at rear of "A" and "B" units for signalling.
4. Valves and cocks.
    a. Nose angle cock is behind the pilot on Fireman's side.
    b. The Steam line valve is behind pilot on engineman's side. The hinged pilot arch sec-

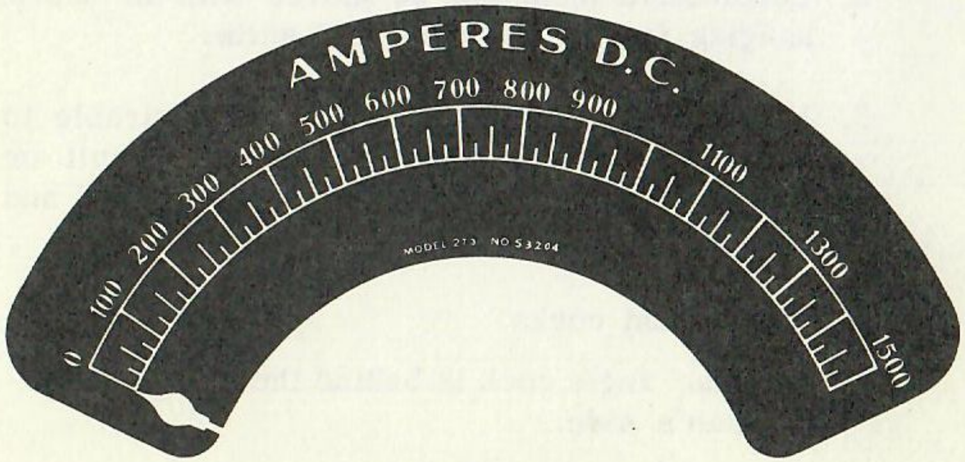
tion of the pilot must be in the raised position to connect steam train line.

c. Train line signal whistle shut-off valve is on signal line reducing valve at front center of brake rack in nose compartment directly ahead of engineman.

5. Pumping up air: If the main reservoir pressure falls below feed valve setting when the brakes are cut in:
    a. Move Generator Field switch to OFF.
    b. Place reverser in NEUTRAL.
    c. Open throttle to 4th, 5th, or 6th notch as needed.

209 **Starting A Train** It would be practically impossible to write a definite instruction for train starting that would apply to all conditions and at all times. Because of the locomotive's very HIGH STARTING TRACTIVE EFFORT it is important that the AIR BRAKES be COMPLETELY RELEASED before attempting to start the train.

The load indicating meter, Fig. 2-8, can be used as a PULL METER to judge the tractive effort of the locomotive. Merely looking at the ground and listening to the engine exhaust may give a false indication of the locomotive's draw bar pull.



Load Indicating Meter
Fig. 2-8

The E9 locomotive is designed to have a comparatively rapid yet smooth build-up of power. Load regulator timing is quite fast in moving from minimum to maximum and somewhat slower from maximum to minimum. This is due to a special design pilot valve bushing in the governor. With this arrangement a power build-up equal to the throttle position is quickly obtained. Any further advancement of the throttle is accompanied by an almost immediate additional increase in power. This may be seen by observing the speed with which the load indicating meter responds to throttle advance.

With a power control of this type the rate of power build-up is left largely to the desire of the engineman yet is still controlled by the load regulator and engine governor.

When ready to start, the following general procedure is recommended:

1. Place the selector lever in the No. 1 position and move the reverse lever to the desired direction.
2. Place foot on the safety control foot pedal (DEADMAN) and release the brakes.
3. Open the throttle one notch every 1 to 2 seconds as follows:
    a. To Run 1 - note that the load meter pointer starts moving to the right.
    b. To Run 2 - note that engine speed increases. At an easy starting place, the locomotive may start the train in Run 2 or 3.

c. To Run 3 or higher - until the locomotive moves. Experience and the demands of the schedule will determine this.

4. Reduce throttle one or more notches if acceleration is too rapid.

E9 TRANSITION POINTS

GEAR RATIO	FORWARD TRANSITION	BACKWARD TRANSITION
57/20	20.5	18.5
56/21	22.0	20.0
55/22	23.5	21.5
52/25	28.5	26.5

NOTE: If the wheel slip indicator flashes continuously reduce the throttle one notch. Apply sand as needed to prevent further slipping and reopen the throttle when rail conditions improve. See Art. 210 Automatic Sanding In Power.

5. It is permissible to keep the pointer at full scale while train is accelerating. As soon as the pointer starts back to the left, open throttle another notch. Continue in this manner until throttle is full open, or until desired speed has been attained.

210 **Automatic Sanding In Power** E9 locomotives are equipped with automatic sanding in power to assist in controlling wheel slip. When operating in transition one (1) sanding automatically takes place while slip is in its initial stage. In this manner a wheel slip is "anticipated" and prevented before any appreciable loss of tractive effort occurs.

In transition 1 and 2 automatic sanding, caused by wheel slip, is accompanied by a reduction in main generator output. Sand is applied in series (1), parallel (2) but not in shunt (3).

Duration of sanding, after the wheel slip has stopped, is controlled by the setting of a time delay sanding (TDS) relay. An off-on circuit breaker switch on the engineman's control panel cuts in or out this sanding-in-power feature.

With the automatic sanding feature "cut-in" (autosanding switch "ON") throttle reduction to avoid repeated wheel slip will rarely be necessary. Also, manual operation of the sanders by the engineman at points on the road where slippage is likely to occur can be eliminated.

211 **Accelerating A Train** With the throttle in Run 8, and the train picking up speed, the indicating meter pointer should move slowly toward the left, under normal rail and load conditions. Continuous operation of the wheel slip light indicates that the tractive effort is exceeding the rail adhesion factor. The engineman should reduce throttle until this condition is corrected.

212 **Locomotive Operation At Slow Speeds** The operation of the E9 locomotive is not governed by any specific short-time ratings, regardless of gear ratio. In most cases the locomotive may be operated up to the limit of the rail adhesion attainable.

E9 locomotives pulling heavy trains at slow speeds should be operated with the throttle in Run 8 position. In the event of a wheel slip indication (wheel slip light flashing on) the locomotive wheel slip control system will automatically apply sand to the rails, and reduce power to a point where slipping stops. (Auto-Sand circuit breaker ON.)

If continuous wheel slipping on sand occurs due to poor rail conditions, the throttle may be reduced. Under these conditions it is possible to continue to operate at reduced throttle, provided it is not necessary to reduce below the 5th throttle position.

Any question which might arise in regard to unusual operating requirements for the E9 locomotives, such as operating in freight service, EMD will, upon request, analyze the actual requirement and make specific recommendations.

BRAKING

213 **Air Braking With Power** The method of handling the air brake equipment is left to the discretion of the individual railroad. However, when braking with power it must be remembered that for any given throttle position the draw bar pull increases rapidly as the train speed decreases. This pull may become great enough to part the train if the throttle is not reduced as the train speed decreases.

Since the pull of the locomotive is indicated by the position of the pointer on the load indicator, it is possible for the engineman to maintain a constant pull on the train during the slow down. This is accomplished by reducing the throttle a notch at a time whenever the amperage begins to increase. When a station stop is contemplated, bear in mind that the throttle must be closed to IDLE before the locomotive comes to a stop. Proper handling of the brake valve at this time is very important in order to accomplish a smooth stop. It is recommended that the independent brakes be kept fully released during power braking.

MISCELLANEOUS OPERATING INSTRUCTIONS

214 **Multiple Unit Operation** In some instances it may be desirable to operate E9 with older units, having different gear ratios, in multiple with each other. In such cases the following precautions should be observed:

1. If some of the units in the locomotive consist have an overload short time rating, operation should be governed by the unit having the HIGHEST maximum permissible speed.
2. If the units of the consist are of different gear ratios, operation should be governed by the unit having the LOWEST maximum permissible speed.
3. The E9 locomotive may be used as a helper or with a helper by observing the basic operating procedures above.

215 Coupling And Uncoupling Units

1. To uncouple units:

    a. Apply brakes and close all angle cocks on both units.

    b. Take down all power plant jumper cables.

    d. Break air hose couplings and separate units by uncoupling.

2. To couple units:

    a. Couple and stretch units to insure that couplers are locked.

    b. Connect air hoses and open angle cocks.

    c. In any non-operating cab, cut out the brakes and place all circuit breakers on the control stand in the OFF position.

    d. Remove reverse lever and air brake handles from their position in the trailing unit.

216 **Changing Operating Ends** When the consist of the locomotive includes two "A" units, the following procedure should be followed in changing from one operating end to the opposite end:

1. If locomotive is equipped with electro-pneumatic brake, and the EP brake has been in use, change the brake shifter lever on the automatic brake valve to "Auto" and open the EP cutout switch.
2. Place transition lever in "OFF" position.
3. REMOVE REVERSE LEVER.
4. Make full service automatic brake reduction.
5. Close brake pipe cutout cock and release safety control foot pedal.
6. With safety control foot pedal depressed, release independent air brake by placing independent brake valve handle in "release" position.
7. Move the Rotair valve to the proper "LAP" position.
8. Move the automatic brake valve handle to "RUNNING" position and remove the handle from the brake valve.
9. Remove the independent brake valve handle in "release" position.
10. Place Generator Field, Engine Run, and Control and Fuel pump circuit breakers in control stand in "OFF" position. Insert locking pin. The electro-pneumatic circuit breaker and signal light breaker (if used) on the electrical control cabinet behind the fireman should also be "OFF."
11. Proceed to cab at opposite end. Open switch lock on control switch panel; close Control and Fuel Pump switch, Engine Run switch and such other switches as are necessary.

12. Insert reverse lever, automatic brake valve and independent brake valve handles. Place independent brake valve in "full application" position.
13. Move the Rotair valve to the proper operating position.
14. Open brake valve cutout cock (double heading cock) slowly, pausing from five to ten seconds in mid-position. Check "PCS" light and reset if necessary.
15. When ready to move locomotive, depress the safety control foot pedal or automatic brake valve handle, and move the independent brake valve to "RELEASE" position.

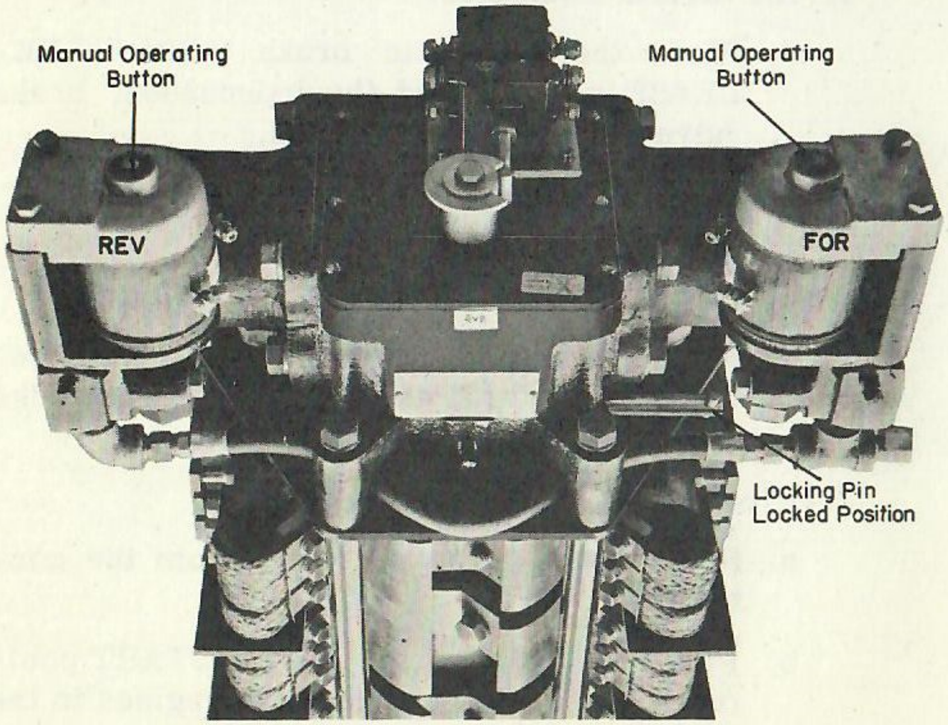
217 **Handling Locomotive Dead In Train**

1. Air Brake Equipment
   a. Place the automatic brake valve in RELEASE position and the independent brake valve in RUNNING position.
   b. Move the double-heading cock to "CUTOUT" position.
   c. Open the "DEAD ENGINE" cut-out cock.
   d. Move the Rotair valve to "PASS" position. The locomotive brakes will now operate like that of a car in the train.
2. Electrical Control Equipment
   a. Remove the reverse lever from the controller.
   b. Place all isolation switches in START position. If necessary to keep the engines in the unit idling while hauling the locomotive, the control and fuel pump circuit breakers must be ON.

c. If the locomotive is to be hauled any appreciable distance dead in a train, it is advisable to place all reverser switches in the neutral position, Fig. 2-9. The switch may be centered in the neutral position by operating the manual operating buttons on the magnet valves if air is available. In case no air is available, this may be done with a pin inserted through the drilled hole through the pin shaft. After centering properly, the lock pin should be inserted into the tapped hole on the right side of the reverser as illustrated in Fig. 2-9. This pin is normally carried on the left side opposite the place shown.

218 Doubleheading

Prior to doubleheading behind another locomotive, make a full service brake pipe reduction with the automatic brake valve and close the doubleheading cock. Leave the Rotair valve in the PASS or FRT position, depending on the type of service, and return the automatic brake valve handle to the running position. The operation of the throttle is normal, but the brakes are controlled from the lead locomotive. The engineman on the second locomotive may make an emergency application of the brakes with automatic brake valve, and/or may release his locomotive brakes by depressing the independent brake valve handle.



Reverser Switch - Locked In Neutral
Fig. 2-9

219 Freezing Weather Precautions

In case the locomotive is to be tied up for any length of time in freezing weather, steam from an external source may be used if available. The following valves should be opened:

1. Engine cooling system.
    a. Steam admission valve to engine cooling water inlet. Both engines.
    b. "G" valves - both engines.
    c. Toilet water tank steam admission valve.
    d. Trainline steam admission valve.
2. Steam generator.
    a. Heating coil valve.
    b. Water suction line valve.
    c. Water tank valve.
    d. For detailed instructions, see Section 6.

In case that no external source of steam is available, the steam generator may be used but at least one engine should be kept in operation as long as the steam generator is in use.

In freezing weather where no source of steam heat is available the entire cooling and heating system should be drained as follows:

1. Open drain valve to all engine cooling systems and remove pipe plug from right water pumps.
2. Drain water from steam generator, and blow out with compressed air.
3. Drain steam generator water tank.
4. Open drain valve to toilet water tank.
5. Drain air system.
    a. Air compressor oil separator.
    b. Sump reservoir.
    c. Main reservoirs.
    d. Type H filter.
    e. Control air reservoir. (All electrical cabinets.)
    f. Control air regulators. (All electrical cabinets.)
    g. Air compressor intercoolers.
    h. Air strainers.

220 **Operation Over Railroad Crossings** When crossing railroad crossings, reduce throttle to the 5th notch or below, before reaching the crossing and leave reduced until all units are over crossing. This will help to reduce arcing from the brushes to the motor commutator.

221 **Running Through Water** Under ABSOLUTELY NO circumstances should the locomotive pass through water which is deep enough to touch the bottom of the traction motor frames. When passing through water, always go at a very slow speed (2 to 3 miles per hour). Water any deeper than three inches above top of rails is likely to cause damage to the traction motors.

222 **Recovering Control After Penalty Application** If "PC" switch is tripped, the locomotive will have power in No. 1 throttle position (shown on load indicating meter) but engine speed will not advance as throttle is opened. In No. 5 or No. 6 throttle position the engines will stop. No bells will ring. If the Engine Run circuit breaker in the cab is open, this will have the same effect as a tripped "PC" switch.

Proceed as follows:
1. Place the automatic brake valve in LAP.
2. Close the throttle to IDLE.
3. Place foot on deadman pedal.
4. Wait until "PC" light goes out.
5. Reset train control if used.
6. Release brakes.

223 **Ground Relay** The pointer points to a yellow dot when set, or to a red dot when the relay is tripped. White alarm light comes on at the engine control panel. Alarm bell will ring if the isolation switch is in the RUN position. When the ground relay is tripped the engine will not speed up when throttle is opened. In No. 5 or 6 throttle position, the engine will stop and the blue alarm light will light. To reset, isolate the engine, reset the relay, and place engine on the line. If relay continues to trip, isolate the engine affected.

224 **Wheel Slip Relay** The wheel slip relay is located in the electrical control cabinet, behind the power contactors. If one pair of wheels should slip while the locomotive is under power, this relay will pick up, lighting the wheel slip light intermittently to warn the engineman that the wheels slip, stop slipping and slip again. The throttle should be reduced to stop the slipping, and sand should be applied to prevent slipping when throttle is reopened.

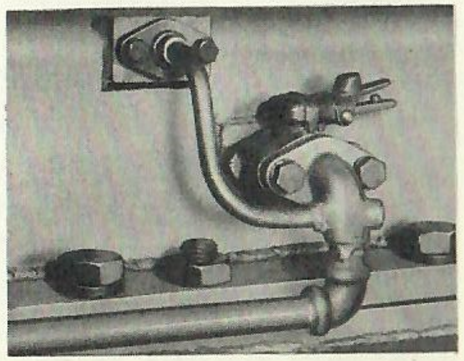
225 **Indication Of A Pair Of Wheels Sliding** If one pair of wheels should slide when starting a train, the wheel slip light will flash on and off intermittently. As the train speed increases, the light will stay on more or less continuously and will not go out when the throttle is reduced. The light will go out when the throttle is closed to idle.

If this occurs, the engine crew should make an immediate investigation to determine the cause. The wheels may be sliding due to a locked brake, a broken gear tooth wedged between the pinion and ring gear, etc.

Repeated ground relay action, accompanied with unusual noises such as continuous thumping or squealing, may also be an indication of serious traction motor trouble that should be investigated at once.

IF A POWER PLANT MUST BE ISOLATED BECAUSE OF REPEATED WHEEL SLIP OR GROUND RELAY ACTION, DO NOT ALLOW THAT UNIT TO REMAIN IN THE LOCOMOTIVE CONSIST UNLESS IT IS CERTAIN THAT ALL OF ITS WHEELS ROTATE FREELY.

226 **Air Box Drains** Each engine has two air box drain tanks incorporated in the engine oil pan near the generator end, one on each side. These tanks have a valve, Fig. 2-10, in the drain line so that the tanks may be drained when the locomotive is standing still, and sludge and oil from the tank will not be carried onto the running gear. Air box drain tanks should be drained regularly.



Air Box Drain Valve
Fig. 2-10

OPERATION OF LOCOMOTIVE "EXTRAS"

227 **Dynamic Brake Operation** Some E9 locomotives are provided with additional electrical equipment permitting a portion of the power developed by the momentum of the train to be converted into an effective negative power, retarding the speed of the train. This feature is known as the dynamic brake and is especially useful as a holding brake on descending grades.

The traction motor armatures, being geared to the axles, rotate whenever the train is moving. When using the dynamic brake, electrical circuits are set up which change the traction motors into generators. Since it takes power to rotate a generator this action retards the train. The power thus generated is dissipated in resistors, called grids, which are cooled by a motor driven fan. The grids and fan are located in the top of the carbody, and a portion of the power generated by the traction motors is used to drive the fan motor.

Before using the dynamic brake a check should be made to see that the unit selector switch, located on the engine control panel, is set to correspond with the number of units in the locomotive consist. (See Art. 228). Following this, place the throttle in Idle, and wait about 10 seconds before moving the selector lever to the "B" position. In the "B" position the dynamic braking circuits are partially established, and depending upon the speed of the train, enough braking power may be present in this position to bunch the slack in the train. If necessary, move the lever beyond "B" and wait until the slack is bunched. After the slack is bunched the lever may be moved farther to the right to give the desired amount of braking effort. The dynamic brake is, in effect, very similar to an independent brake and the load indicating meter serves the purpose of a "brake cylinder pressure gauge."

On E9 locomotives the dynamic brake circuit is equipped with a regulator which automatically limits the braking amperage to a maximum of 700 amperes regardless of locomotive speed or selector handle position.

Placing the selector handle in "B" position will result in a certain amount of grid current depending upon locomotive speed and generator residual voltage. At maximum speed, if the throttle has been in idle at least ten seconds before moving the selector handle to "B" position, this slight residual voltage will result in about 200 amperes at the grids.

NOTE: As the BKT power-braking transfer switch does not move when the selector handle is moved from "RUN" to "OFF," generator residual current will not affect the dynamic braking circuit when the selector handle is in "OFF" position.

Movement of the selector handle from "B minimum" toward "B maximum" will result in increased braking (grid) current. Also, as soon as the lever leaves the "B minimum" position engine speed will increase to 425 RPM to insure that higher traction motor blower speed is obtained to furnish additional cooling for the traction motors. When the handle has been advanced beyond the position required for 700 ampere braking, the dynamic brake regulator will operate to give the main generator shunt field the proper amount of "buck" excitation. This will result in a net generator excitation value for 700 ampere braking.

If maximum dynamic braking is desired, the selector handle may be advanced slowly to the right toward "B maximum" position. Once 700 amperes has been reached, further movement of the selector handle will result in a braking current exceeding 700 amperes as long as the handle is being advanced, but will reduce to a nominal 700 amperes a few seconds after the handle is stopped. This momentary overcurrent (indicated by the load ammeter, and possibly brake warning light flashing) is not harmful, and no attempt should be made to reduce the braking current manually by moving the handle back and then advancing it again. Such an effort to put out the light will probably result in the regulator hunting. Instead, it is suggested that the selector handle movement be stopped until the light goes out. The light MUST GO OUT WITHIN 15 SECONDS after the handle movement has been stopped. If handle movement is stopped when 700 ampere braking is reached and the train speed increases, the braking current will not exceed a nominal 700 amperes.

The range (and purpose) of the regulating system is such that it is impossible to exceed a nominal 700 ampere braking current, except momentarily, regardless of locomotive speed or selector handle position.

When necessary, the automatic brake may be used in conjunction with the dynamic brake. However, the independent brake must be KEPT FULLY RELEASED whenever the dynamic brake is in use, or the wheels may slide. As the speed decreases below 10 miles per hour the dynamic brake becomes less effective. When the speed further decreases, it is permissible to completely release the dynamic brake by placing the selector lever in the "OFF" or "RUN" position, applying the independent brake simultaneously to prevent the slack from running out.

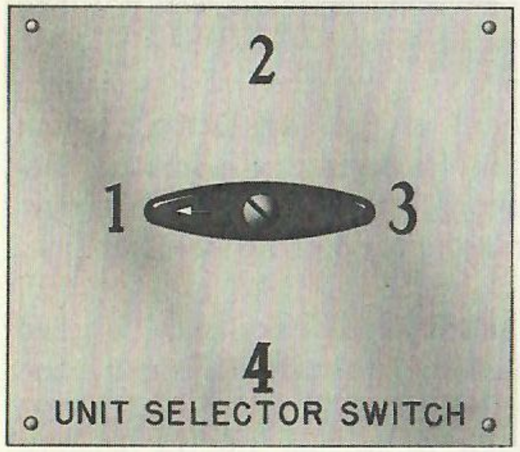
The most effective use of the dynamic brake is between 15 and 25 miles per hour depending on the gear ratio. Speed on grades should not be allowed to "creep up" by careless handling of the air brakes. The dynamic brake is intended as a holding brake and is not very effective in slowing down heavy trains on steep grades.

NOTE: a. If either power plant in a unit is isolated, the dynamic brakes in that unit will be inoperative.

b. If the #1 power plant in a locomotive is shut down, the field loop circuit is inoperative and the dynamic braking action of the locomotive will be negligible.

228 Unit Selector Switch (Dynamic Brake Only)

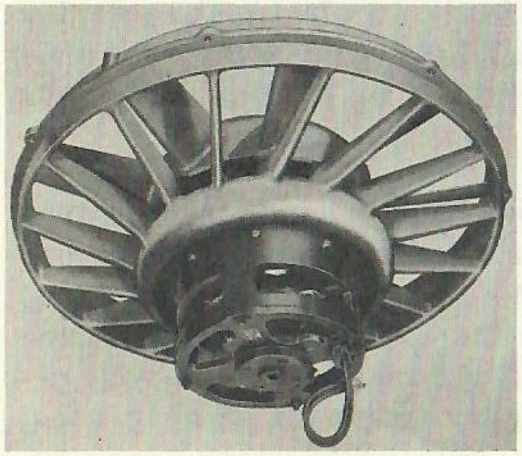
The unit selector switch located next to the engineman's instrument panel has four positions, only three of which are used. It should be set to correspond to the number of units making up the locomotive, Fig. 2-11. The unit selector switch should be set before leaving the maintenance point. If one or more engines should be isolated in route, this switch must not be changed. The only time this switch is changed is when the locomotive consist is changed.



Unit Selector Switch
Fig. 2-11

229 Dynamic Brake Grid Blower

The brake blower motor drives a blower which supplies air for cooling the dynamic braking grids, Fig. 2-12. There is one brake blower motor in each unit. It operates only when the dynamic brake is being used. In the event of failure of a motor, or blower, the dynamic brake must be cut out on that unit to prevent overheating or burning up the grids. For information on "Isolating Engine While Using Dynamic Brake" see Art. 203.



Dynamic Brake Grid Blower
Fig. 2-12

230 Dynamic Brake Warning Light

A dynamic brake warning light is installed on locomotives equipped with dynamic brakes to indicate excessive braking current. In general, the current limiting regulator will correct this condition by reducing the current to 700 amperes as explained in Article 227.

231 Dynamic Brake Wheel Speed Control

Under certain operating conditions during dynamic braking operation, a pair of wheels may tend to rotate at a slower speed than normal, due to unusual rail conditions.

When this occurs the retarding effect of the traction motors is reduced and sand is automatically applied to the rails, the wheel set resumes normal rotation, and the retarding effect of the traction motors returns (increases) to its former value. Automatic sanding continues for approximately 20 seconds after the condition has been corrected.

232 Operating "B" Unit With Hostler's Controls

Operation at the hostler station in a "B" unit is the same as in an "A" unit. The push-button switches are beside the controller and the brake valve cutout cock is below the brake valve. The bell valve is a globe valve near the controller. It should be remembered that the operation of the "B" unit controls will operate all units joined to it.

When securing the hostler control be sure that all push buttons are pulled out, that the controller and reverser levers are pinned, and that the brake valve is cut out. These items will affect operation from any other station or cab.

SECTION 3

LOCATION AND CORRECTION OF DIFFICULTIES ON-THE-ROAD

This section provides a check list to call the operator's attention to the troubles which are most frequently encountered on the road, and which can be quickly remedied, thereby eliminating many delays.

No attempt is made to explain general operation and functions of the equipment on the locomotive. For such information, refer to the other sections of this manual.

The locomotive automatically protects its equipment in case of the faulty operation of most any component. There are two general ways that this protection is obtained: (1) by automatically reducing the engine speed to Idle, or (2) by automatically stopping the engine. An exception is a hot engine alarm which does not change the engine load. In this case the enginemen must take action to reduce the loading on the affected engine until the condition is corrected as explained in Art. 300.

In most cases the general location of difficulty is indicated by the alarm bell ringing and the lighting of signal lights in the affected unit. These lights are:

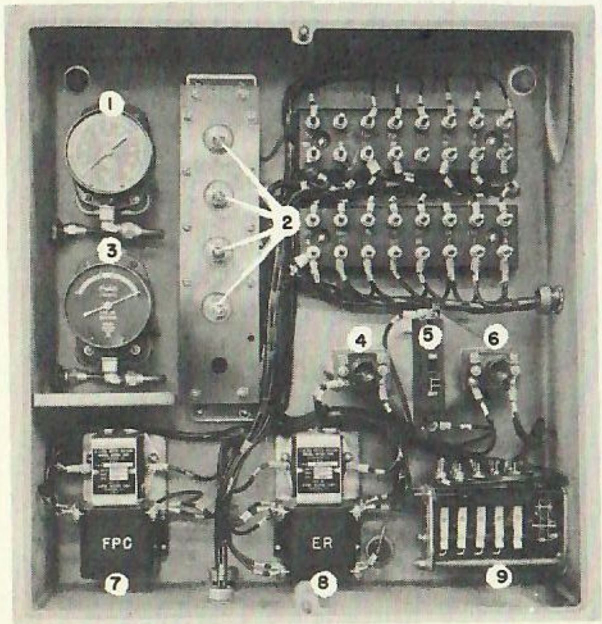
a. Hot Engine - RED
b. Boiler Stopped - GREEN
c. No Power - BLUE
d. PC Switch or Ground Relay - WHITE

NOTE: All circuit breaker type switches on the engineman's control panel are rated at 15-amperes; except Control and Fuel Pump and Generator Field, which are 30-ampere circuit breakers.

The circuit breaker switches are ON (closed) when in the UP position; OFF-DOWN.

If a circuit breaker is overloaded and trips open, service is restored by first placing the switch to full OFF and then moving it to ON.

300 **If Alarm Bells Ring** A signal light will light on the engine control panel of the engine affected, Fig. 3-1.



1. Lube Oil Pressure
2. Alarm Lights
3. Lube Oil Suction
4. Engine Stop Button
5. Fuel Pump Switch
6. Engine Start Button
7. Fuel Pump Contactor
8. ER Relay
9. Isolation Switch

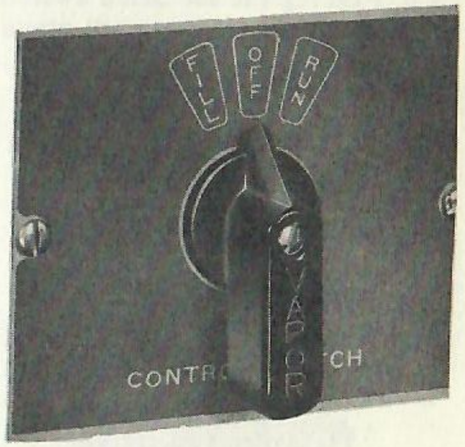
Engine Control Panel
Fig. 3-1

RED—Hot Engine Indicates outlet engine water temperature over 208° F. Water temperature gauge will be in the red area. This alarm does not cause a change in engine load or speed. Isolating engine does not extinguish alarm light — alarm bell stops when the temperature returns to normal.

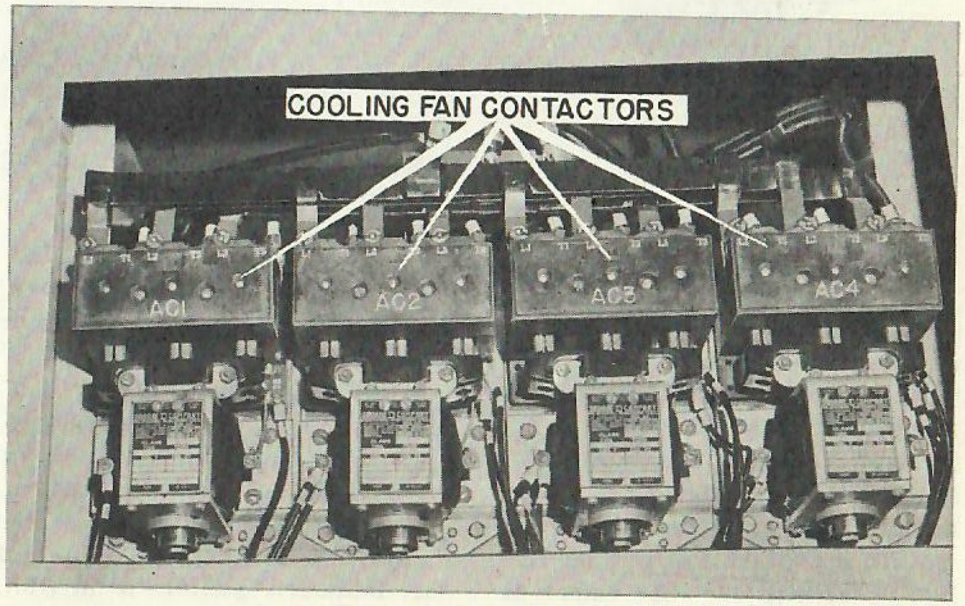
In case of hot engine indication, proceed as follows:

See that AC cooling fan contactors, Fig. 3-2, are closed (check reset buttons), shutters are open, and water level is correct. If a summer-winter switch is provided, check its position. The Control and Fuel Pump switch circuit breaker in the engineman's control panel must be ON, or the cooling system fan and the shutter control will be inoperative. If condition cannot be quickly corrected, isolate the engine and investigate, allowing engine to idle. The position of the engineroom winterization hatch control damper should be checked.

GREEN—Boiler Stopped Indicates that the steam generator has stopped. To stop alarm bell, turn boiler switch OFF, Fig. 3-3. To correct, see



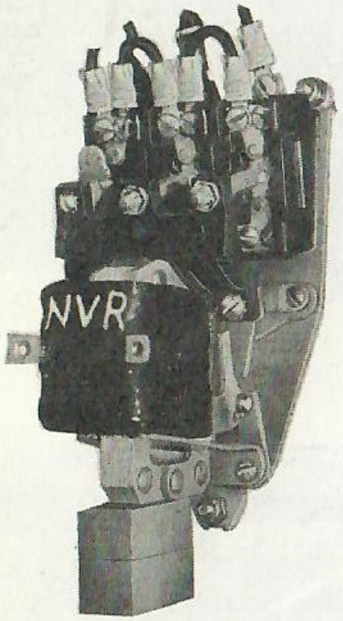
Boiler Switch
Fig. 3-3



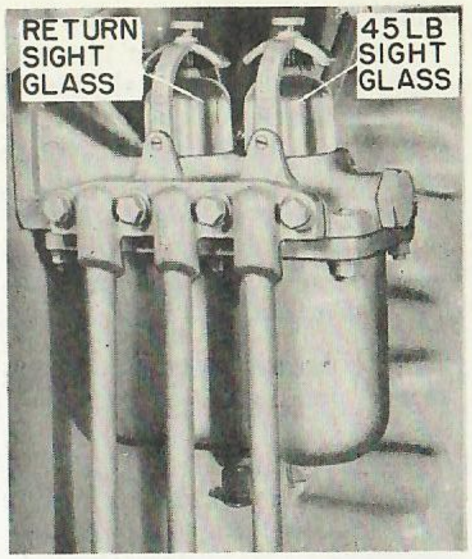
AC Cooling Fan Contactors
Fig. 3-2

Steam Generator Trouble Shooting Chart Section 6.

BLUE—Alternator Failure Indicates an alternator failure; the bell and light are operated by de-energizing the NVR, Fig. 3-4. This reduces engine speed to Run 1, or to STOP if the throttle is in Run 5 or 6. Placing the isolation switch in START (engine isolated) stops the alarm signals.



No Voltage Relay
Fig. 3-4



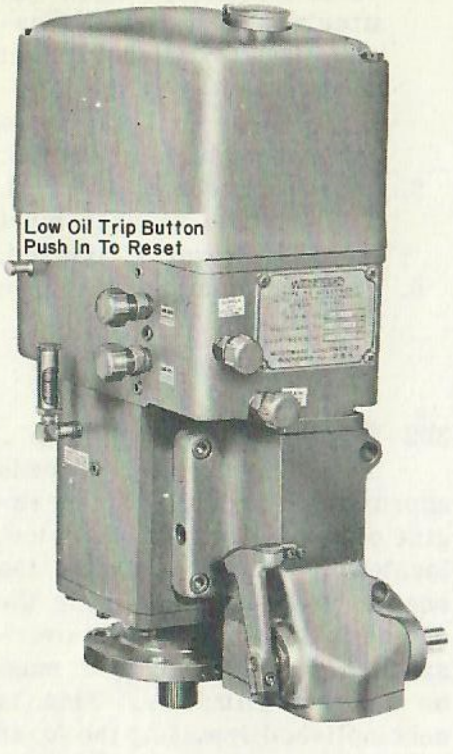
Fuel Sight Glass
Fig. 3-5

Most No Power failure alarms, caused by lack of AC voltage, are "false" since this alarm occurs if the engine stops for any reason while "on the line." With an alternator alarm and the engine stopped, ALWAYS isolate and start the engine before checking for the cause of "failure." Check the overspeed trip and fuel flow, Fig. 3-5, before trying to start an engine that has shut down with no indication other than an alternator failure. If other alarm indications are present with the alternator alarm, they must also be checked before starting the engine.

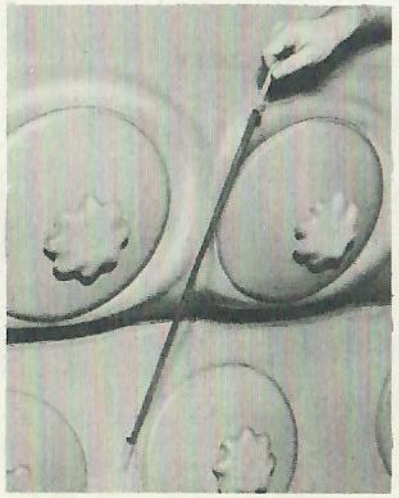
A true alternator (AC) failure is evident if the blue alarm light and alarm bell are energized while the engine is running with the isolation switch in RUN—"on-the-line."

With a true AC failure, check the auxiliary generator field fuse.

YELLOW—Low Oil Pressure The tripping of the governor low oil pressure alarm button, Fig. 3-6, will always stop the engine and will give an alarm if the isolation switch is in Run. Isolate the engine and reset the low oil trip button. Check oil level, Fig. 3-7, and if OK, start the engine. Check the oil pressure, and place engine "on-the-line." Do not repeatedly start the engine if the governor persists in shutting the engine down.



Low Lube Oil Reset Button
Fig. 3-6

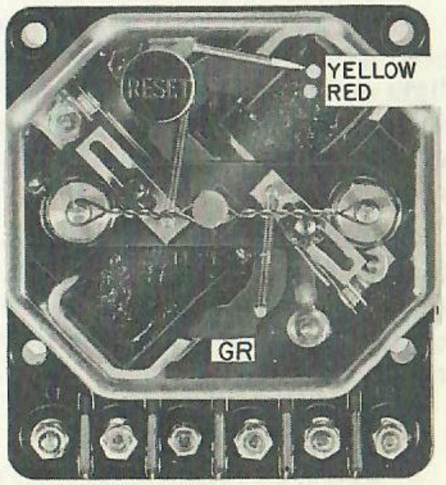


Engine Oil Pan Dipstick
Fig. 3-7

If a low oil pressure alarm should stop the engine while "on-the-line," a blue alternator failure light will also indicate, since stopping the engine also stops the generation of alternating current.

WHITE—Ground Relay When the ground relay light on the engine control panel is on, it indicates a tripped ground relay (indicator pointing to red dot). This stops the power output of that power plant and causes the engine speed to be reduced to Idle — or to Stop if the throttle is in Run 5 or 6. If the ground relay trips, the alarm bell will sound if the isolation switch is in the Run position.

To correct: Isolate the engine, reset the ground relay, Fig. 3-8, and place engine "on-the-line." If ground relay continues to trip, leave the engine isolated.



Ground Relay
Fig. 3-8

UNDER NO CONDITION OF REPEATED WHEEL SLIP ACTION OR GROUND RELAY ACTION SHOULD A POWER PLANT BE ISOLATED AND ALLOWED TO REMAIN IN THE CONSIST UNLESS IT IS CERTAIN THAT ALL OF THE WHEELS ARE ROTATING FREELY.

ADDITIONAL SAFETY DEVICES

301 **PC Switch** The pneumatic control switch, often called the "power cut-off" switch, is an air operated electric switch that is tripped open by any penalty or emergency air brake application. When open, this switch reduces the power output of all engines to Idle (or to Stop if the throttle is left in Run 5 or 6). Whenever the PC switch is tripped, a white (PC Switch Open) indicating light on the engineman's control panel will show, but the alarm bell will not ring.

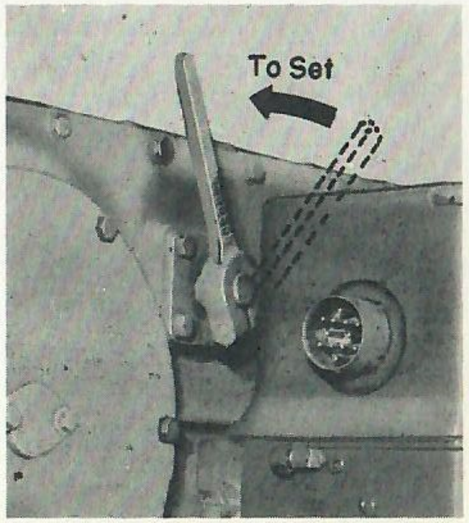
If the engine stops, the blue alternator failure alarm light on the engine control panel will show when the PC switch is reset, and the alarm bell will ring.

The PC switch is automatically reset provided the throttle is returned to Idle, and control of the brake is recovered. To reset:

1. Close throttle to IDLE.
2. Place automatic brake valve in LAP.
3. Place foot on safety control foot pedal.
4. Wait until application pipe builds up to normal pressure; listen for exhaust or watch PC switch light. If, after an emergency application, the PC switch does not reset itself with the automatic brake in LAP, move the brake valve to RUNNING.
5. Reset train control (if used). ATC circuit breaker must be ON. Reset if tripped.
6. Place automatic brake valve in RUNNING.

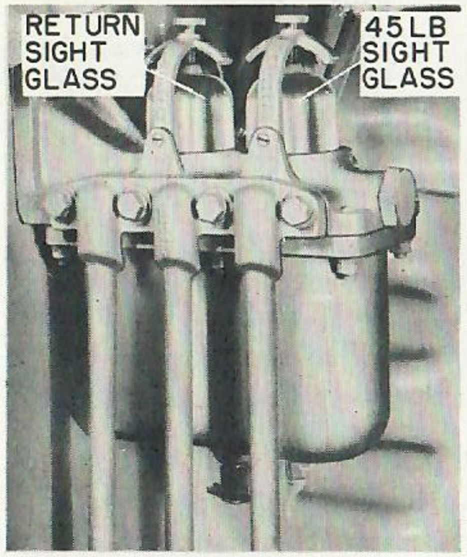
302 **Engine Overspeed Trip**

If the engine speed exceeds approximately 910 RPM, an engine overspeed protective device, located in the front end of the engine, will trip and bring the engine to STOP. Once this overspeed device is tripped it must be reset manually. This is accomplished by pulling the lever counter-clockwise until it latches, Fig. 3-9.



Engine Overspeed Trip
Fig. 3-9

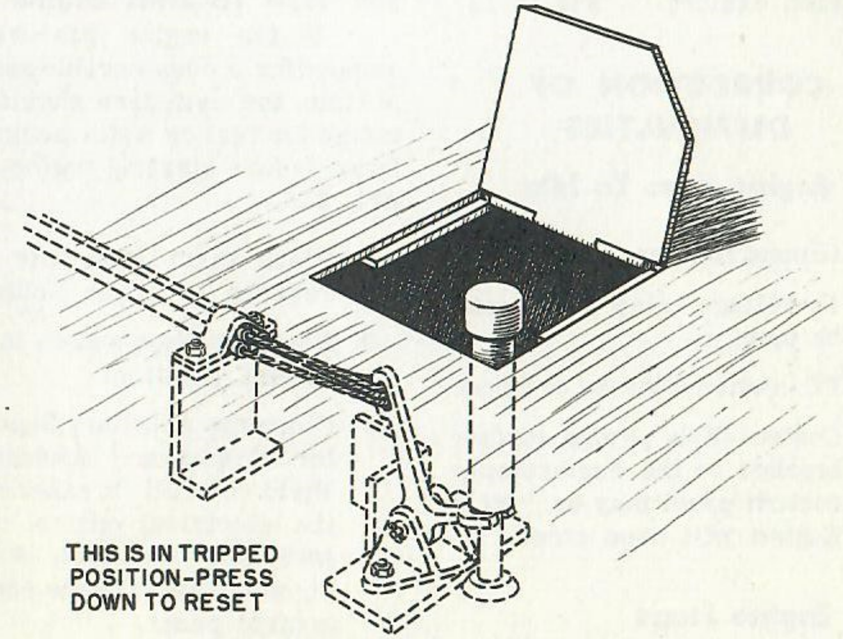
303 **Fuel Flow** For proper operation, a good flow of fuel (clear and free of air bubbles) should be indicated in the fuel return sight glass located on the sintered bronze filter assembly, Fig. 3-10.



Fuel Sight Glass
Fig. 3-10

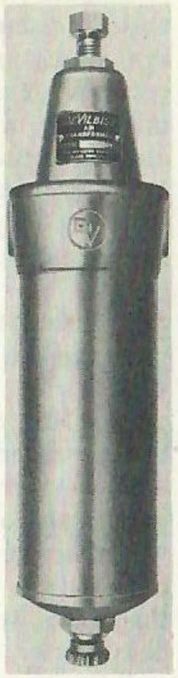
If fuel is not flowing through the 5-pound return sight glass, check fuel pump motor. If motor is stopped, check fuel pump circuit breakers and switches on the control panels, and the cable connection to motor. If the pump is running but fuel is not flowing, check the fuel supply, emergency fuel cutoff valve, suction leak in piping, plugged suction filter, or a slipping fuel pump coupling.

304 **Emergency Fuel Oil Cutoff Valve** If fuel is not flowing in the sight glasses of the No. 1 and No. 2 engines in the same unit, check to see that the emergency fuel cutoff valve has not been tripped. This valve is located under the floor between the engines, and is reset through a trap door in the carbody floor. To reset, step down solidly on reset rod, Fig. 3-11. If this valve is properly set, the suction filters may be clogged.



Emergency Fuel Cutoff Reset
Fig. 3-11

305 **Control Air Pressure Regulator** The control air for operating power contactors, reverser and brake transfer switch is supplied from the main reservoir and reduced to 90 ± 3 p.s.i. by the control air regulator, Fig. 3-12. The pressure regulator is located behind the steps leading into the operating cab on the right (engineman's) side of the locomotive. The pressures are indicated on gauges mounted on each of the electrical control cabinets. Separate cutout cocks are provided for each cabinet.



Control Air Regulator
Fig. 3-12

CORRECTION OF DIFFICULTIES

306 Engine Goes To Idle

1. Ground relay may be tripped.
2. No voltage relay (NVR) may be open.
3. PC switch may be tripped.
4. Control-Fuel Pump circuit breaker on the engineman's control panel may be "Off." Engine will soon stop.

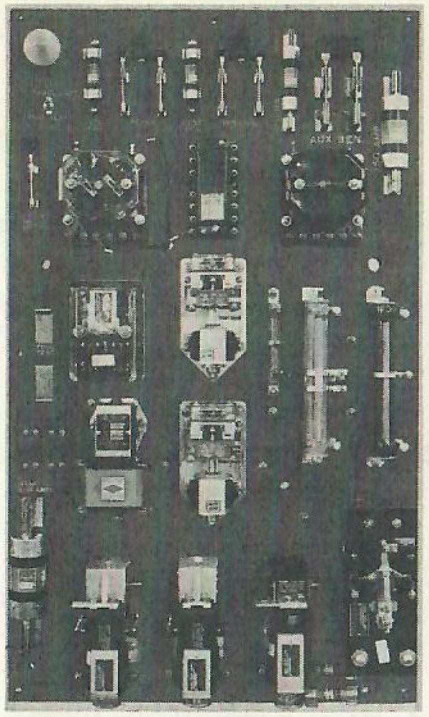
307 Engine Stops

1. Throttle may be in STOP position.
2. Low oil pressure button on the governor may be "out."
3. Engine overspeed device may have tripped.
4. No voltage relay (NVR) may have opened with throttle in RUN 5 or 6.
5. Ground relay may have tripped with the throttle in RUN 5 or 6.
6. PC switch may have tripped with the throttle in RUN 5 or 6.
7. Fuel pump circuit breaker on the engine control panel may be "Off."
8. Control-Fuel Pump circuit breaker on the control panel may be "Off."
9. Emergency fuel cutoff valve may be tripped.
10. Check fuel supply.

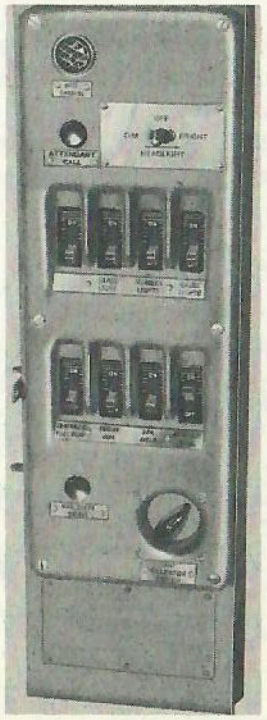
308 How To Start Engine

If the engine has been stopped for a considerable period of time, the cylinders should be tested for fuel or water accumulation before starting engine, see Art. 315.

1. Place throttle in Idle and reverse lever in Neutral.
2. Place isolation switch in the START position.
3. Close the Auxiliary Generator Field and Alternator Field circuit breakers on the electrical control cabinet, and the Fuel Pump circuit breaker in the engine control panel.
4. Close all switches on the distribution panel, Fig. 3-13.



Distribution Panel
No. 1 Cabinet
Fig. 3-13



Engineman's Panel
Fig. 3-14

5. At the engineman's control panel turn ON the "Control-Fuel Pump" circuit breaker.
6. After allowing a few seconds for fuel to flow through the return sight glass, solidly press the START button and hold until the engine starts. If the engine fails to start after 15 seconds of rotation, check for possible troubles listed under Art. 307 before again trying to start engine.
7. After allowing time for the lube oil pressure to build up, place the isolation switch in RUN position.

309 The Engine Does Not Rotate When "Start" Button Is Pressed

1. "Control-Fuel Pump" circuit breaker on the engineman's control panel must be ON, Fig. 3-14.
2. Isolation switch must be in the START position.
3. 400-ampere starting fuse must be in place, and good.
4. Main battery switch and the control knife switch in the electrical cabinet must be closed.

310 The Engine Rotates But Does Not Start When "Start" Button Is Pressed

1. Low oil pressure button on the governor must be pressed "IN."
2. Engine overspeed trip must be set.

3. Fuel pump circuit breaker in the engine control panel must be ON.
4. Emergency fuel cutoff valve must not be tripped.
5. Adequate fuel supply to injectors should be indicated by fuel flow in sight glass.

311 The Engine Does Not Speed Up When Throttle Is Opened

1. "Control and Fuel Pump" circuit breaker on the engineman's control panel must be ON.
2. Isolation switch must be in RUN position.
3. PC switch must not be tripped.
4. Ground relay must not be tripped, Fig. 3-8.
5. No voltage relay (NVR) must not be open. Auxiliary generator field and alternator field circuit breakers must be ON.
6. Control knife switch in electrical cabinet must be closed.

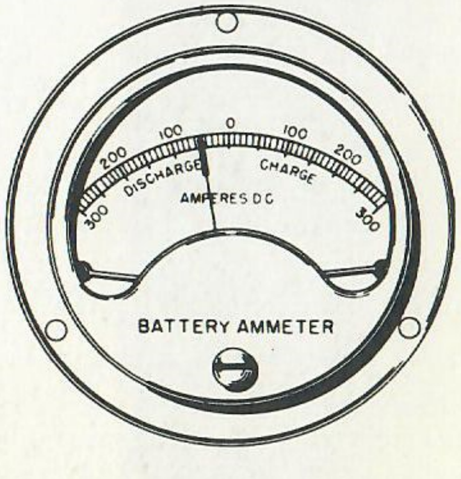
312 The Engine Speeds Up But Locomotive Does Not Move When Throttle Is Opened

1. Reverse lever must be in either reverse or forward position.
2. Generator field circuit breaker must be ON.
3. There must be 90 p.s.i. control air pressure and 150 ampere auxiliary generator fuse must be good.
4. 70-ampere battery field fusetron must be good.
5. Hand and air brakes must be released.
6. "Engine Run" circuit breaker must be ON.

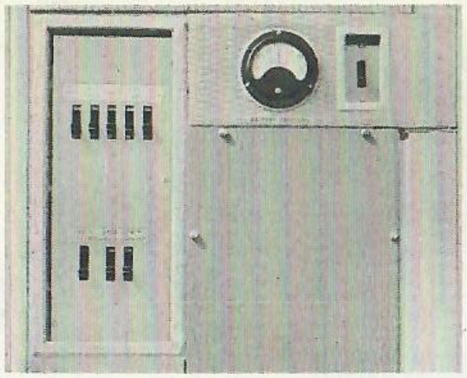
313 Battery Ammeter Shows Continuous Discharge

Fig. 3-15.

1. Battery charging contactor located in the electrical cabinet must be closed.
2. The Auxiliary Generator Field circuit breaker on the electrical cabinet must be ON, Fig. 3-16.
3. The Auxiliary Generator switch on the electrical control panel must be closed and the 150 ampere fuse must be in good condition.



Battery Ammeter
Fig. 3-15



Auxiliary Generator
Field Circuit Breaker
Fig. 3-16

314 Air Compressor Control

The air compressors are driven through a flexible coupling from the front end of each Diesel engine. This is a two cylinder, two stage, water-cooled compressor. The loading and unloading of each air compressor is controlled by a mechanical governor, Fig. 3-17. The unloading device will normally maintain main reservoir pressures between 130-140 p.s.i. In case of trouble, the air compressors may be manually loaded by re-positioning the shut-off cock. (Special electrical unloader equipment is in use on some locomotives.)

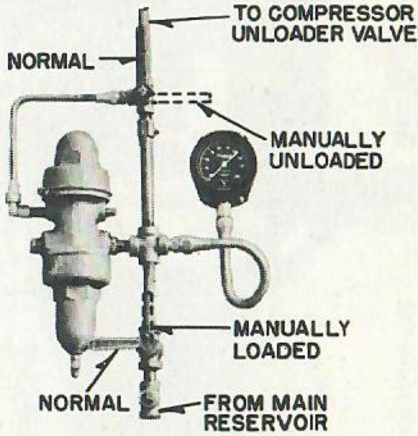
315 Cylinder Test Valves

Each cylinder is equipped with a test valve for the purpose of testing for fuel or water accumulation in the cylinders.

Prior to starting an engine that has been shut down for a considerable period of time, proceed as follows:

Remove the 400-ampere starting fusetron, open all cylinder test valves approximately 3 full turns, and use the engine jacking tool to rotate the engine one complete revolution. If liquid is discharged from any cylinder, investigate and correct the condition, if not, close the cylinder test valves, replace 400-ampere starting fuse, and start engine in the usual manner.

If the engine is running and any cylinder test valve is leaking, the engine should be stopped, and the valve(s) tightened, using the pin-wrench supplied for this purpose.



Compressor Unloader Valve
Fig. 3-17

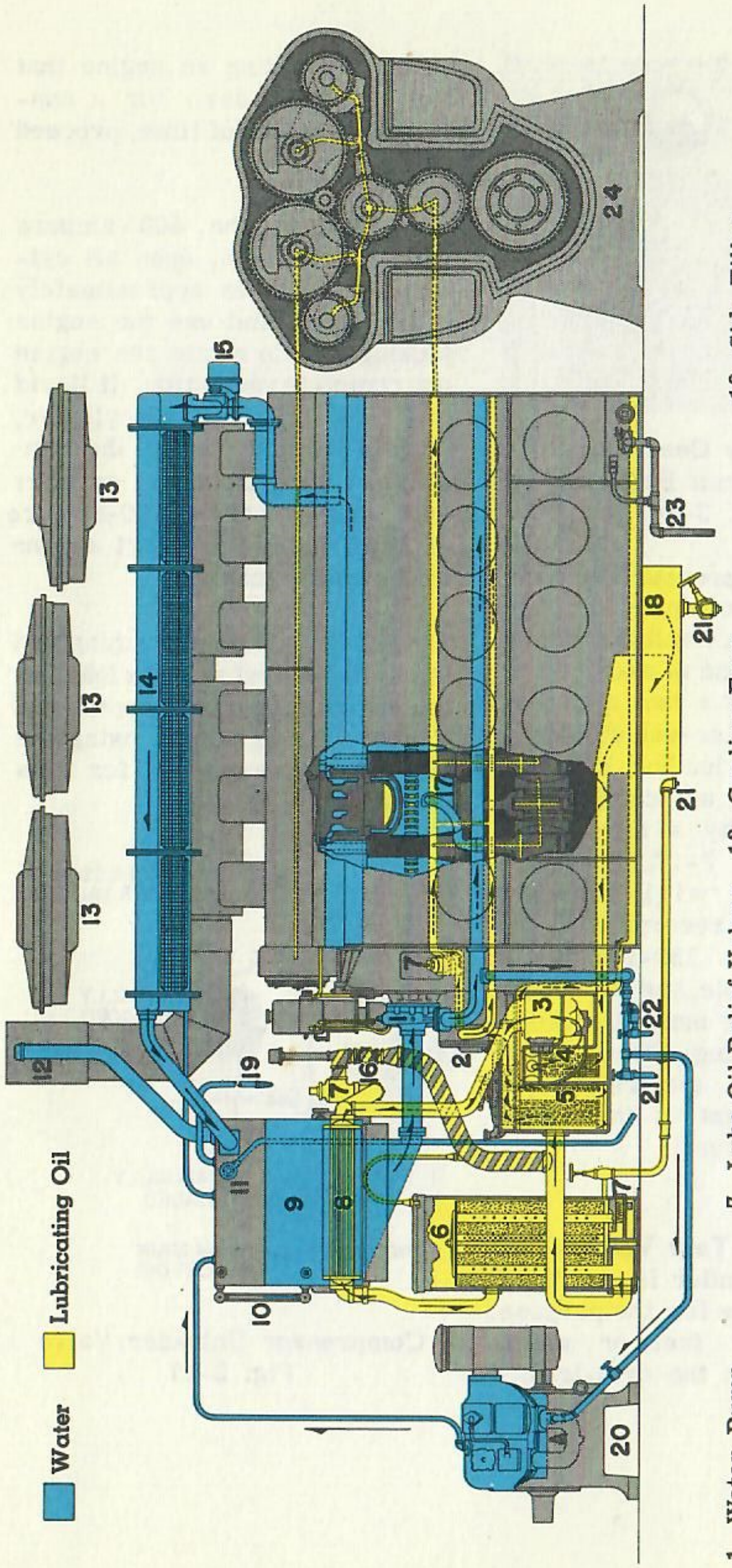


Fig. 4-1 - Schematic Of Cooling And Lube Oil Systems

1. Water Pump
2. Lubricating Oil Pump
3. Scavenging Oil Pump
4. Sump Oil Strainer
5. Lube Oil Strainers
6. Lube Oil Filter
7. Lube Oil Relief Valves
8. Lube Oil Cooler
9. Cooling Water Tank
10. Water Level Gauge
11. "G" Valve
12. Roof Filler
13. Cooling Fans
14. Radiator
15. Thermostat Switch
16. Lube Oil By-Pass Sight Glass
17. Cylinder Liner
18. Engine Sump
19. Side Filler
20. Air Compressor
21. Drains
22. Steam Admission Line
23. Air Box Drain
24. Camshaft Drive Gear Train

SECTION 4

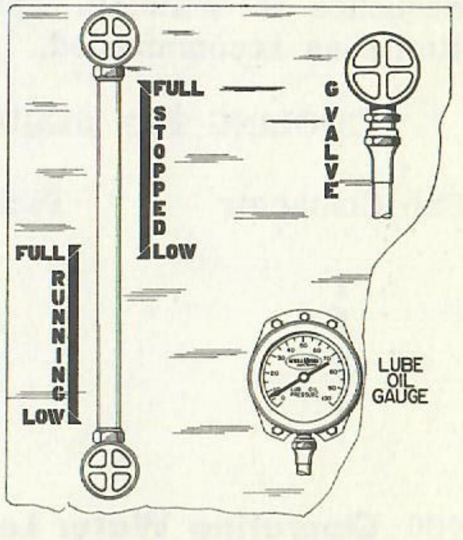
ENGINE COOLING, LUBRICATING OIL, FUEL OIL AND VENTILATING SYSTEMS

The piping systems of all EMD locomotives are identified by colors applied to the valves, pipe unions, flange fittings, and other portions of the system. This applies to the steam generator as well as to the engine and locomotive piping systems. The color code is as follows:

Red	Fuel Oil
Yellow	Lube Oil
Light Blue	Hot Water
Dark Blue	Cold Water
Orange	Steam
Green	Air

ENGINE COOLING SYSTEM

A schematic flow diagram of the engine cooling and lube oil system is shown in Fig. 4-1. The cooling water is circulated through the cooling system by gear driven centrifugal water pumps mounted on the accessory end (FRONT END) of the engine. Water is drawn from the engine cooling water tank, Fig. 4-2, which also houses the lube oil cooler, and is forced through the engine and into



Cooling Water Tank
Fig. 4-2

the radiators where it is cooled. The water flows through the radiators and returns to the water tanks and oil coolers. The water pumps then start the cooling water back through another cooling cycle.

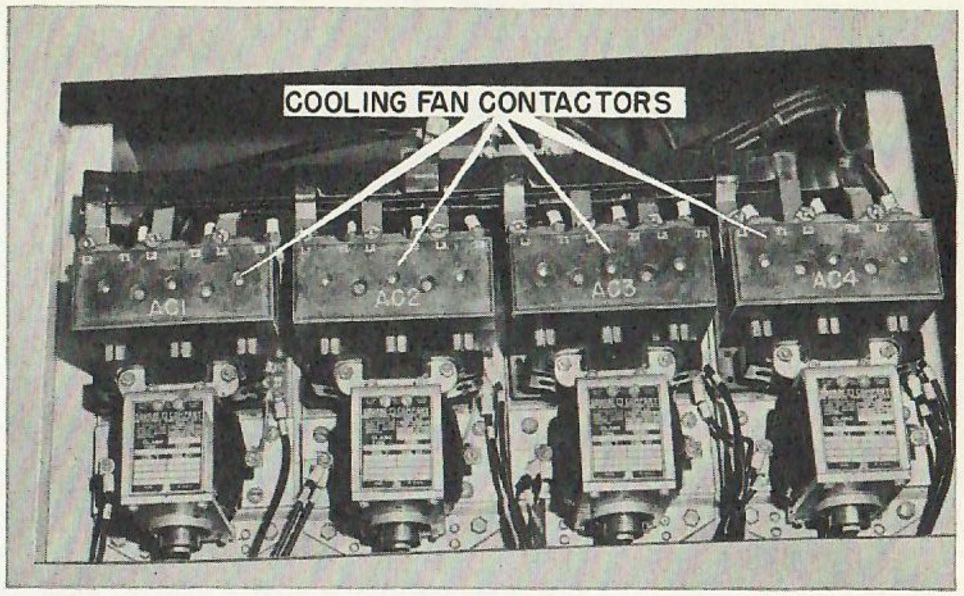
The radiators are built in two banks consisting of four sections each, and are mounted above the engines. Water discharged from the engine is divided between the two banks of radiators. Three cooling fans are mounted above each engine group of radiators.

Outside air is admitted to the cooling hatch through the flat filters and is controlled by automatically regulated shutters. As the air flows through the filters and passes through the radiators, it absorbs heat from the cooling water and exhausts the heated air out through the roof of the carbody. As the temperature of the cooling water rises, a temperature control switch located in the engine cooling water inlet elbow will actuate to cause the cooling fans to operate and the shutters to open. The sequence of operation is controlled by the thermostatic switch, and the AC motors are in turn controlled by the AC contactors, Fig. 4-3. An increase in engine temperature will cause more fans to operate and the decrease in temperature will cut out fans in sequence to maintain operating temperatures within limits as recommended.

COOLING FAN SEQUENCE OF OPERATION

Fan Contactor	Pickup (°F)	Dropout (°F)
1	170	160
2	174	164
3	178	168
4	182	172

400 **Operating Water Level** Operating water levels are stenciled on the water tank next to the water gauge glasses to indicate minimum and maximum water



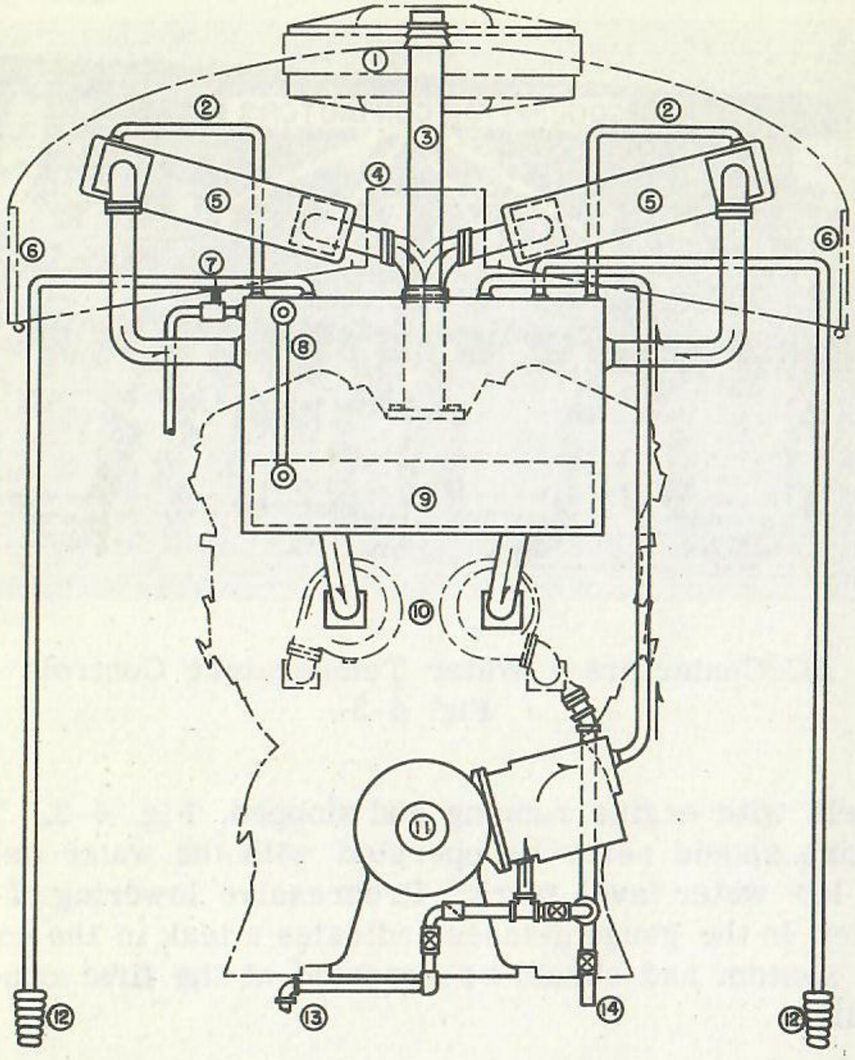
AC Contactors - Water Temperature Controls
Fig. 4-3

levels with engine running and stopped, Fig. 4-2. The engine should never be operated with the water below the low water level mark. Progressive lowering of the water in the gauge glasses indicates a leak in the cooling system and should be reported at the first opportunity.

401 **Filling Cooling System** The system is filled either through the filler pipe located on the roof of the locomotive, Fig. 4-4, or through the filler pipe at the center of the unit on either side.

To fill the system proceed as follows:

1. Stop the engine.
2. Open filling level valve "G."
3. Fill slowly until water runs out the filling level pipe at valve "G."
4. Close the filling level valve "G."



1. Cooling Fan
2. Radiator Vents
3. Roof Filler Pipe
4. False Ceiling
5. Cooling Radiators
6. Cooling Air Intake
7. "G" Valve
8. Water Sight Gauge
9. Lube Oil Cooler
10. Cooling Water Circulating Pumps
11. Water Cooled Air Compressor
12. Filler Hose Cones
13. Steam Admission Pipe
14. Drain Pipe

Cooling System Schematic
Fig. 4-4

If filling a dry or nearly dry engine also follow these additional steps:

5. After the preliminary filling, start engine and run several minutes to eliminate any air pockets in the system.
6. Shut down the engine and open valve "G," and wait 3 minutes.
7. Add water until it runs out filling level pipe.
8. Close the filling level valve "G."

NOTE: If the cooling system of a hot engine has been drained, do not refill with cold water until the engine has had a chance to cool down. The sudden change in temperature may cause the cylinder liners and heads to develop cracks, or warp to the extent that water leaks will develop.

CAUTION:
1. Do not attempt to fill the cooling system through the drain pipe located underneath the locomotive.
2. The system should not be filled above the maximum water level indicated on the water tank.
   a. To prevent freezing of radiators in winter.
   b. To prevent loss of rust inhibitor when draining back to "G" valve level.

402 Draining Cooling System

A. Open water drain valve (compressor end of engine).

B. Open drain petcock under water pump (fuel-glass side).

The entire cooling system can be drained by opening the drain valve near the deck at the front end of the engine. This is with the exception of some water which will be trapped in the right hand water pump. This can be drained by removing the pipe plug in the bottom of the water pump housing.

403 **Cab Heater** A cab heater is located on each side of the cab. Steam from the steam line passes through the heaters and motor driven fans provide air circulation. The output of each heater may be varied by positioning the cab heater switches. These switches have four positions "OFF" 1, 2, 3, which provide three different motor speeds.

CAB HEATING AND VENTILATING SYSTEM

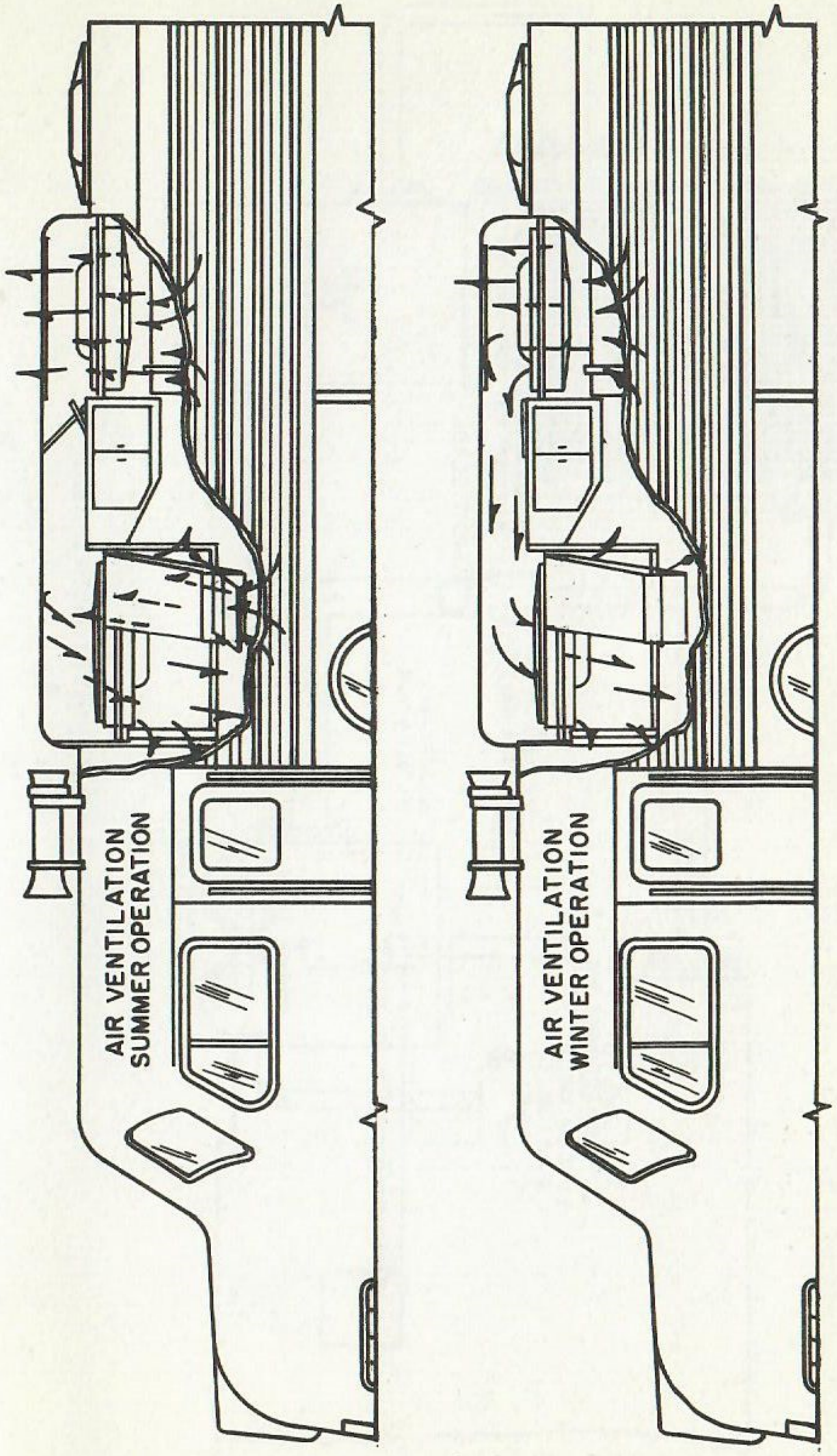
404 **Ventilating System** Two ventilating fans in the roof of the locomotive (one for each power plant) supply air to the engineroom for engine scavenging, air compressors and main generator and traction motor cooling. Fig. 4-5.

Air hoods are built onto the locomotive roof covering the ventilating fans, and extending over the No. 1 engine cooling fan on each power plant. An open grill is located over the No. 1 cooling fans, allowing the fans to exhaust to atmosphere.

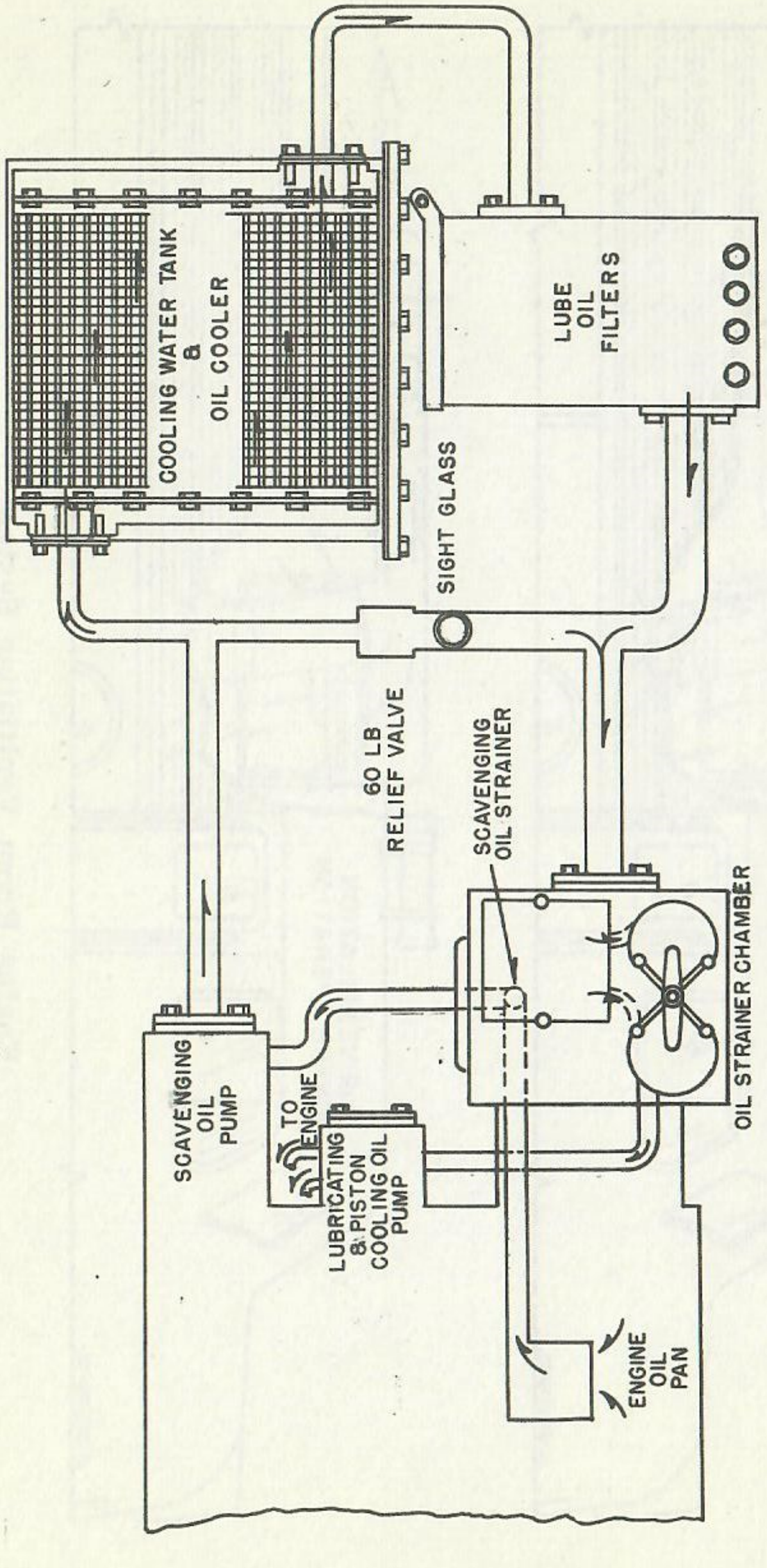
A movable damper is placed in each hood, between the ventilating fan and the cooling fan.

Air ducts with movable dampers extend from the carbody sides to the hood over the ventilating fan.

The dampers in the air ducts and in the hood over the ventilating fans are controlled by two levers, one on the air duct on the left side and at the front of the engineroom; the other at the rear of locomotive on the right side.



Engine Room Ventilating System
Fig. 4-5


COOLING WATER TANK & OIL COOLER
LUBE OIL FILTERS
SIGHT GLASS
60 LB RELIEF VALVE
SCAVENGING OIL STRAINER
OIL STRAINER CHAMBER
SCAVENGING OIL PUMP
TO ENGINE
LUBRICATING & PISTON COOLING OIL PUMP
ENGINE OIL PAN

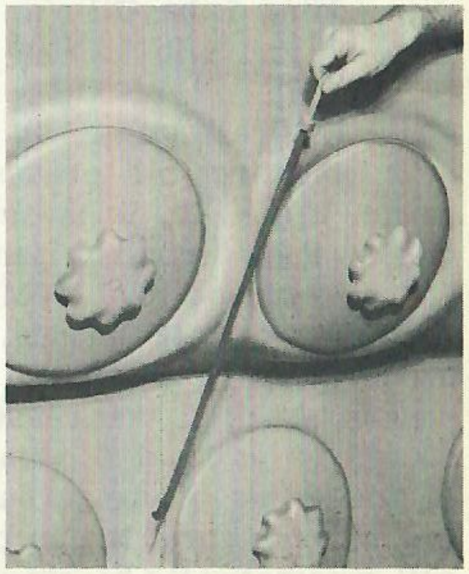
Lubricating Oil System Schematic
Fig. 4-6

With the lever in Summer position, the damper in the hood overhead between the ventilating fan and the No. 1 cooling fan is closed, and the dampers in the air ducts on each side of the locomotive are open. Outside air enters the air ducts, goes up to the hood, down through the ventilating fans and through the air filters into the engineroom.

With the lever in Winter position, the side dampers are closed, excluding outside air, and the damper in the hood between the ventilating fan and No. 1 cooling fan is open. The ventilating fan will now draw in some of the warm exhaust air from the No. 1 cooling fan, forcing this warm air through the filters and into the engineroom.

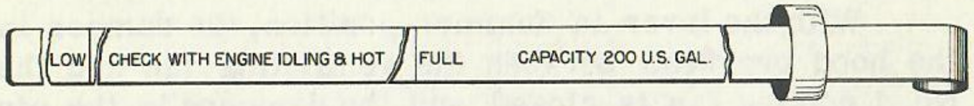
LUBRICATING OIL SYSTEM

Oil under pressure is forced through the engine for lubrication and piston cooling by the duplex piston cooling and lube oil pump. Lube oil which drains into the oil pan is picked up by the scavenging oil pump and forced through the oil cooler and filters to the oil strainer housing where it is ready for recirculation by the oil pump. The excess returns to the oil pan where it is held until used. Fig. 4-6.



Lube Oil Level
Fig. 4-7

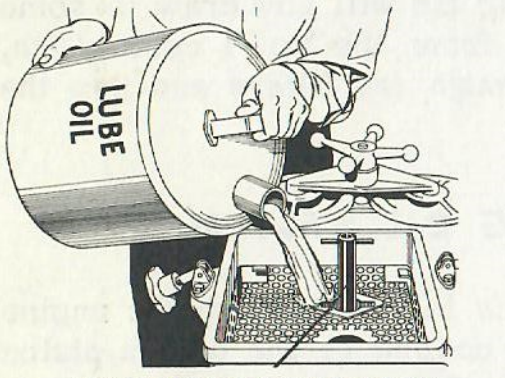
405 **Oil Level** The oil level should be checked, Fig. 4-7, with the engine hot and running at idle speed. The dipstick should show a level between "Low" and "Full," Fig. 4-8. A dipstick is located on the right side of the engine. When the engine is stopped,



Lube Oil Dipstick
Fig. 4-8

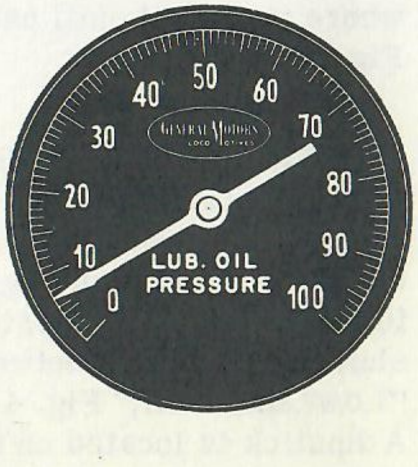
the oil in the filter and cooler will drain back into the oil pan. If the oil level is checked with the engine stopped, the reading on the dipstick will be above the "Full" mark.

406 **Adding Oil To System** Oil may be added with the engine running or stopped. When oil is added to the system, it MUST be poured through the opening having the square cover, Fig. 4-9, on top of the strainer housing. Should the round caps be removed while the engine is running, hot oil under pressure will come from the openings and possibly cause personal injury.



Adding Lube Oil
Fig. 4-9

407 **Oil Pressure** A lubricating oil pressure gauge, Fig. 4-10, is mounted on the engine control panel. Oil pressure at 800 RPM is normally 35 to 45 pounds. It should not drop below 20 pounds. At IDLE the pressure should be at least 6 pounds. In the event of dangerously low oil pressure the engine will automatically be stopped by action of the governor low oil pressure button.



Oil Pressure Gauge
Fig. 4-10

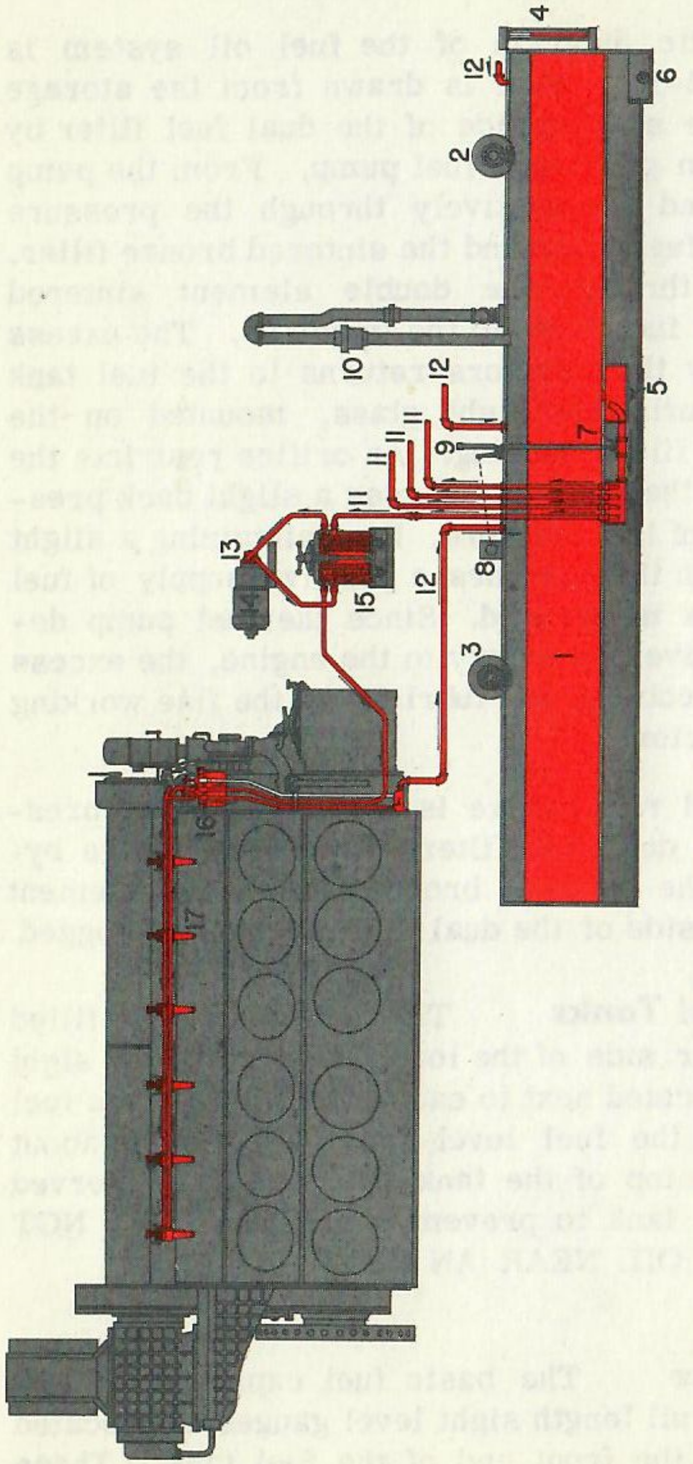
FUEL OIL SYSTEM

A schematic diagram of the fuel oil system is shown in Fig. 4-11. Fuel is drawn from the storage tank through the suction side of the dual fuel filter by the motor driven gear type fuel pump. From the pump the fuel is forced consecutively through the pressure side of the dual fuel filter and the sintered bronze filter. After passing through the double element sintered bronze filter the fuel flows to the injectors. The excess fuel not used by the injectors returns to the fuel tank through the return fuel sight glass, mounted on the sintered bronze filter housing. An orifice restricts the flow of fuel into the glass and causes a slight back pressure of fuel out of the injectors. By maintaining a slight back pressure on the injectors a positive supply of fuel for the injectors is assured. Since the fuel pump delivers an excessive fuel supply to the engine, the excess fuel is used for cooling and lubricating the fine working parts of the injectors.

A 15 pound relief valve is built around the pressure side of the dual fuel filter. This relief valve by-passes fuel to the sintered bronze filter if the element in the pressure side of the dual filter becomes clogged.

408 **Filling Fuel Tanks** The fuel tank can be filled from either side of the locomotive. A short sight level gauge is located next to each fuel filler. This fuel gauge indicates the fuel level from the top to about 4-1/2" below the top of the tank and should be observed while filling the tank to prevent overfilling. DO NOT HANDLE FUEL OIL NEAR AN OPEN FLAME.

409 **Fuel Gauge** The basic fuel capacity is 1200 gallons. Full length sight level gauges are located on each side of the front end of the fuel tank. These gauges indicate the level of fuel in the tank below the low level of the short fuel filler gauge.

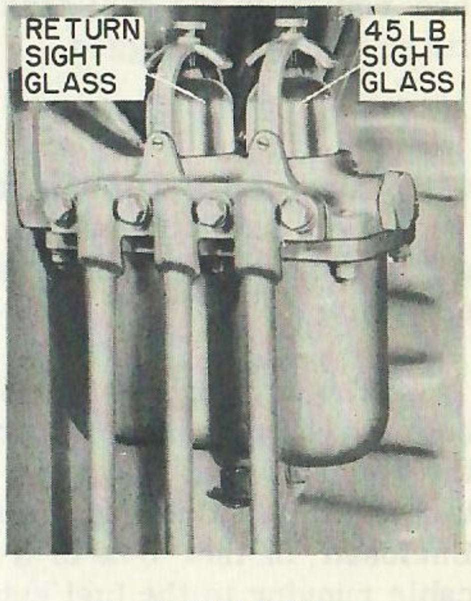


1. Combination Fuel And Water Tank
2. Fuel Filler
3. Boiler Water Filler
4. Fuel Sight Glass
5. Fuel Tank Drain Plug
6. Water Tank Drain Plug
7. Emergency Fuel Cutoff Valve
8. Emergency Fuel Cutoff Valve Pull Ring
9. Emergency Fuel Cutoff Valve Reset
10. Vent And Flame Arrestor
11. Fuel Supply Lines
12. Fuel Return Lines
13. Fuel Pump
14. Fuel Pump Motor
15. Oval Fuel Filter
16. Sintered Bronze Filter And Sight Glass Assembly
17. Injector

Fuel Oil System
Fig. 4-11

410 **Fuel Sight Glasses** Two fuel sight glasses, Fig. 4-12, are mounted on the sintered bronze filter housing.

For proper engine operation, a good flow of fuel (clear and free of bubbles) should be indicated in the sight glass nearest the engine called the "fuel return sight glass." With no fuel showing in the fuel return sight glass, check to see that fuel pump motor is running.



Fuel Sight Glass
Fig. 4-12

If fuel pump motor is running, and no fuel is flowing in return sight glass, check the following:

1. Fuel supply in fuel tank.
2. Position of emergency fuel cutoff valve.
3. Clogged suction filter.
4. Suction leak in piping between tank and pump.
5. Broken or slipping coupling at fuel pump.

If fuel pump motor is stopped, check the following:

1. Control and fuel pump circuit breaker.
2. 15 ampere "fuel pump" circuit breaker on engine control panel.
3. Control knife switch must be closed.
4. Main battery switch must be closed.
5. Loose fuel pump motor cable connection.

The sintered bronze filter is also equipped with a 45-pound relief valve and sight glass. This sight glass is referred to as the "45-pound sight glass" and is normally empty. When more than a trickle of fuel is seen in the 45-pound sight glass, it is an indication that the relief valve is open. Fuel will pass through the 45-pound sight glass and relief valve to by-pass the engine and return to the fuel tank in case the sintered bronze filter becomes clogged.

411 **Emergency Fuel Cutoff Valve** An "emergency fuel cutoff valve" is provided to cut off the fuel supply to the fuel pump in the event of fire, or any emergency.

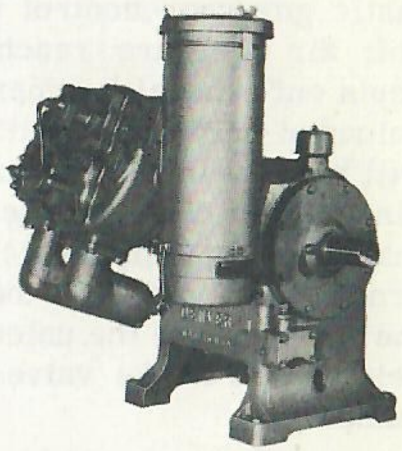
The trip and reset lever is accessible through a hole in the engineroom floor, in the cross aisle between the two engines. On each side of the locomotive, attached to the side skirt, is a small box with a lift cover. Enclosed in this box is a pull ring on the end of the cable running to the fuel cutoff valve. A similar ring is located in the operating cab of each "A" unit.

The fuel cutoff valve can be tripped, and the fuel cut off by pulling any one of these rings, or by pulling up on reset lever. If tripped, the valve may be reset by pushing down on the reset lever.

AIR SYSTEM

Compressed air is not only used on a Diesel locomotive for operating the air brakes and sanders but is also essential for the proper operation of many other items. The reverser switch, main power contactors, shutter operating cylinder, horn, bell and windshield wipers are also air operated. Some of the items mentioned are merely electro-pneumatic valves. This means that in such cases the flow of air, through the valve, is controlled by electrical circuits.

412 **Air Compressor** A Model ABO air compressor, Fig. 4-13, is directly driven from the crankshaft of each engine through a flexible coupling. The compressors are two cylinder, two stage, water cooled type, rated at 112 CFM at 800 RPM. The compressor has its own oil pump and pressure lubricating oil system. The crankcase lube oil level may be checked with either the engine running, or shut down by checking the oil level in the sight glass on the back side of the compressor. The oil level should be at or near the full mark in either case. The two cylinders are set on the crankcase at an angle of 20 degrees above horizontal, the cylinders and cylinder heads are cored for circulation of water for cooling. This water is piped from the cooling system drain line on the engine. It circulates from the bottom of the low pressure cylinder up and out through the top of the high pressure cylinder and into the engine cooling water tank.



ABO Air Compressor
Fig. 4-13

The ABO compressor uses a manifold type intercooler with a relief valve set at 55 pounds. Each compressor has a crankcase breather, mounted on top of the crankcase or lube oil filler pipe, which acts as a check valve and maintains a partial vacuum in the crankcase. An oil separator in the discharge air line from the high pressure cylinder filters oil droplets and carbon particles out of the air.

413 **Compressor Control** Since the air compressor is directly connected to the engine, the compressor is in continuous operation whenever the engine is

running. An unloader piston is provided in the head of each high and low pressure cylinder which cuts out the compressing action when actuated by air pressure from the compressor governor control. The unloader accomplishes this by blocking open the intake valves of the high and low pressure cylinders. When the air operating the unloader is cut off, the unloader releases the intake valves and the compressor resumes pumping. Main reservoir air pressure is used to actuate the unloader valves.

Both air compressors are controlled by one pneumatic governor control system. When the main reservoir air pressure reaches 140 pounds, the governor "cuts out" the air compressors by admitting air to the unloader valves. Admitting air to the unloader valves will hold the intake valves open, preventing the compressing action. The compressors remain unloaded until the main reservoir pressure falls to 130 pounds. The governor then "cuts in" the air compressors by stopping the air supply to the unloader valves, the unloader valves release the intake valves and the compressors resume pumping.

414 **Draining Of Air System** The air system should be drained periodically to prevent moisture from being carried into the air brake and electrical control air system. The frequency of draining will depend on local conditions and can be determined by practice. It is recommended that draining be done at the time of each crew change, until a definite schedule can be determined by the individual railroad.

SECTION 5

ELECTRICAL EQUIPMENT

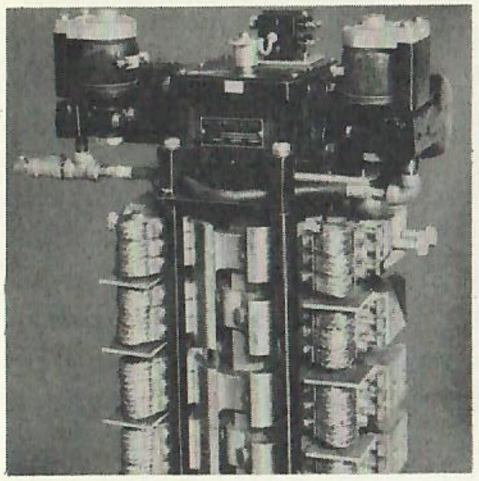
500 **Basic Electrical Systems** The electrical equipment for the No. 1 power plant is duplicated for the No. 2 power plant on the E9 locomotive, with the exception of the storage battery which is common to both power plants in the unit. The engineman's controls in the "A" unit cab will operate both power plants in unison, or either one independently of the other, depending upon the position of the two isolation switches. The schematic wiring diagram identifies the components to each power plant by the number one (1) or two (2) following the initial letters, such as FTR-1 and FTR-2.

Each of the two power plants requires three separate electrical systems which may be classified as the (1) low voltage system, (2) the high voltage system and (3) the alternating current system.

The low voltage systems use a common 64 volt storage battery as a source of power with the two auxiliary generators supplying battery charging current. A voltage regulator is connected in the charging circuit to maintain the auxiliary generator output to the required level of 72 to 74 volts. The low voltage system also includes equipment for engine starting and engine speed control, engine cooling control, locomotive lighting, alarm bells and lights. Also all component parts of the locomotive control systems which are necessary to operate the high voltage switch gear between the main generator and the traction motors. On locomotives equipped with dynamic brakes, additional low voltage control equipment is required for the transmission and regulation of the power generated by the traction motors to the resistor grids.

The high voltage systems of the E9 locomotive have their sources at the two main generators. The

No. 1 main generator powers the two traction motors mounted on the No. 1 truck (1 and 2) and the No. 2 main generator powers the two traction motors on the No. 2 truck (3 and 4). The power switching equipment for the No. 1 power plant includes the power contactors P1, P2 and S12, the reverser, forward transition relays and related interlocks, Fig. 5-1.



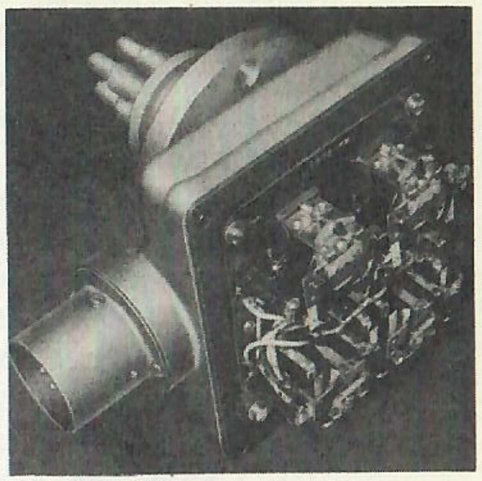
Reverser Switch
Locked In Neutral
Fig. 5-1

The No. 2 power plant consists of essentially the same equipment with the exception of the power contactors which are identified as P3, P4 and S34.

In dynamic braking, on locomotives so equipped, each pair of traction motors generate power independently of the other pair. Their power is converted to heat and dissipated to atmosphere in separate resistor grid banks mounted on a common frame. Each power plant has its individual brake transfer switch for transferring the traction motor connections from power to braking position and back to power from the braking position.

Both power plants in the E9 locomotive unit have their individual alternating current systems originating at their respective alternators. Field excitation for the alternators is derived from the auxiliary generators and the power generated is used to operate the four cooling fans. The fan operation depends upon engine cooling water temperature and is regulated by a thermostatic type switch, Fig. 5-2.

The alternator output is adjusted to 149 volts with engine speed at 800 RPM and three fans running. A no voltage relay (NVR) is connected across two phases of the "Y" connected alternator and is energized during normal operation. Should a failure occur to the alternator, the NVR relay becomes de-energized, closing an alarm circuit to warn the engineman of the condition.



Thermostatic Switch
Fig. 5-2

501 **Reading Schematic Wiring Diagrams**

The "schematic" for the E9 locomotive shows the two power plants with the components marked to indicate with which power plant the device is associated. At the bottom of each schematic wiring diagram the sections of the diagram are identified as follows:

1. Control - Engineman's control in cab of "A" unit.
2. Temperature Control - Thermostatic switches and fan contactors for engine cooling temperature.
3. #1 Transmission Control - Power switches, reverser, shunt and battery field contactors related interlocks for controlling locomotive movement, at No. 1 power plant.
4. #2 Transmission Control - As above for No. 2 power plant.
5. #1 Engine Control - Engine speed governor control No. 1.
6. #2 Engine Control - Engine speed governor control No. 2.
7. Alarm - Bell and light alarm system for both #1 and #2 power plants and steam generator alarm.
8. #1 Power Transmission - Main generator and traction motors for No. 1 power plant

plus all related high voltage switch gear, resistors, brake transfer switch and reverser connections.

9. #1 Battery Charging And Engine Cooling - Auxiliary generator, voltage regulator, reverse current relay and battery, plus the engine cooling fan circuits as connected to the alternator.
10. #2 Power Transmission - Same as #1 power transmission except for #2 power plant.
11. #2 Battery Charging And Engine Cooling - Same as No. 1 except for No. 2 power plant.
12. Lighting - All lamps, switches or circuit breakers necessary to the engineroom and cab lights. Includes locomotive headlight and gauge lights, classification lights and all other equipment connected through the two pole single throw knife switch marked "LIGHTS."

Any portion of a circuit may first be located by referring to the proper section of the "schematic" -- then, finding the particular component desired. For example, should it be desirable to find what constitutes a circuit to operate the S12 power contactor. In this case it is advantageous to locate the S12 operating coil in the #1 Transmission Control section of the diagram, and work backward to the source of power.

The "N" negative wire is common to all low voltage contactors, relays and valves on EMD locomotives and returns to the negative post of the battery. S12 is the second magnet coil to the right of the dividing line between Transmission Control and Temperature Control sections, see schematic wiring diagram. A wire designated as 8E is connected to the positive side of the magnet coil, then to the P2 contactor through the normally closed NC (normally closed) interlocks a-b. Wire 8D then connects to the NC interlocks, j-k, of transition relay No. 1 - TR1. Wire 8C then connects at a junction point and through the NC interlocks a-b of generator starting contactor No. 1 - GS1. Here the circuit is divided to pass through interlocks (either of two sets of interlocks a-b or g-h) of brake relay BR. As the g-h interlocks are normally closed with the locomotive pulling a train, these interlocks are in the circuit and the a-b interlocks are open. (In dynamic braking the reverse is true.) Brake transfer switch No. 1 BKT1 is closed between points R and Q to the 8B wire which connects to the g-h interlocks of the isolation switch - IS. Reverser RVR1 may be in either position to close the c-d or e-f interlocks as shown. However, for this example, assume that RVR is in the forward position connected to the FO wire. This FO wire terminates at the reversing drum at the engineer's control stand in the CONTROL section of the diagram. The G wire connects the FOR segment of the reversing drum to the "hot" segment of the throttle. When the throttle is in any position from No. 1 to No. 8, the PC wire connects to the 30 ampere Control and Fuel Pump circuit breaker, to the PO wire which then connects to a 60 ampere fuse, thence to the positive terminal of the battery.

This brief explanation describes how the one S12 contactor operating coil is energized and shows what fuses, circuit breakers and interlocks are involved. The continuity of any circuit of either power plant may be traced out in the same manner.

502 **Alphabetical Legend and Electrical Symbols** and a basic schematic wiring diagram are included at the end of the manual.

AUXILIARY CONTROL CIRCUITS

503 **Fuel Pump Circuit** The two fuel pumps required on the E9 locomotive may be operated individually or together by establishing the proper circuits.

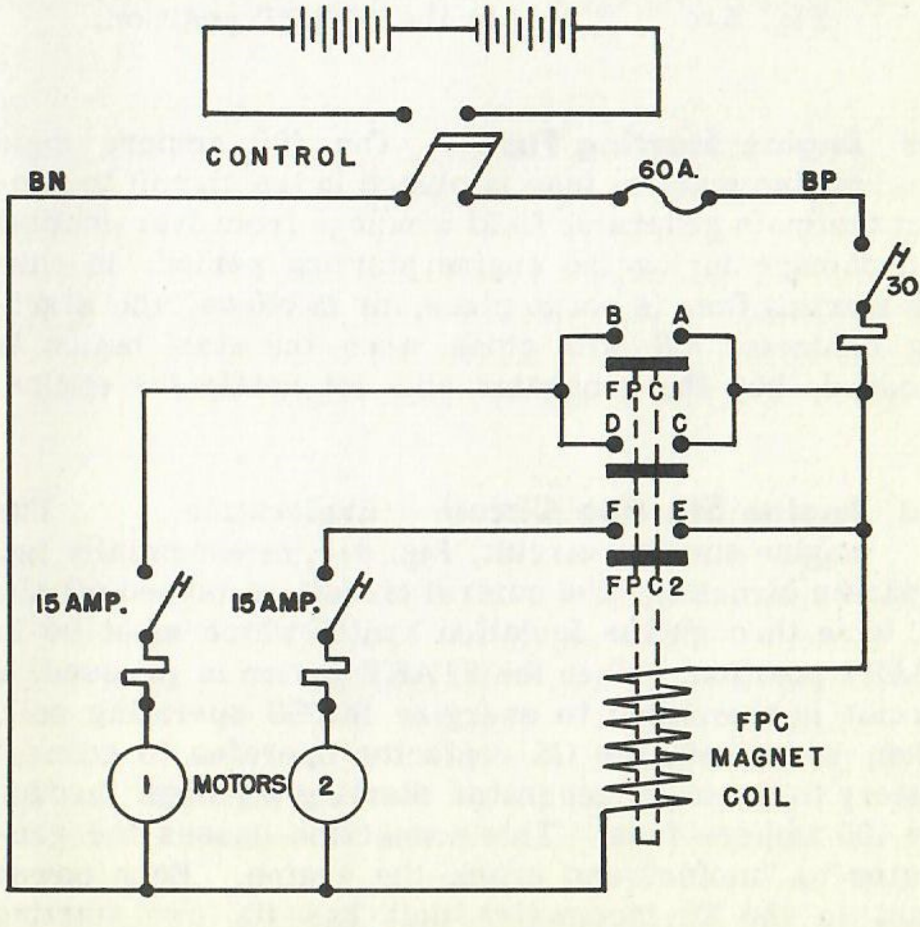
The fuel pump circuit contains the two motors which drive the fuel pumps to supply fuel to each of the Diesel engines in the unit. One 30 ampere circuit breaker located at the engineer's control stand connects the battery to the fuel pump circuits through a fuel pump contactor.

504 **Fuel Pump Contactor (FPC)** One fuel pump contactor is used per unit. The NO (normally open) contacts a-b and c-d are connected in parallel for operating the circuit to the No. 1 fuel pump motor and the e-f contacts are connected to the power supply for the No. 2 fuel pump. The operating coil is energized at the engineman's control stand by closing the 30 ampere Control and Fuel Pump circuit breaker.

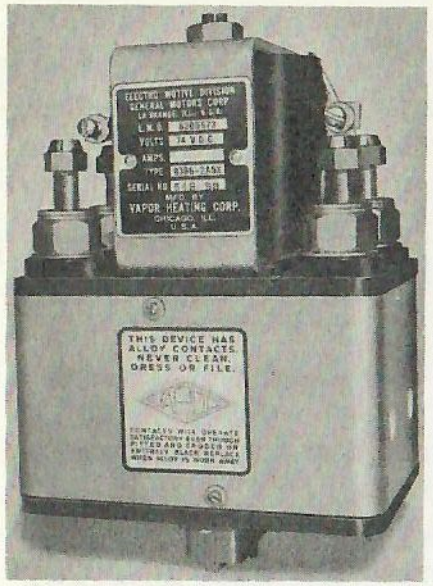
505 **Fuel Pumps** One fuel pump is required for each Diesel engine in the E9 unit. They are directly connected to the fuel pump motors by a flexible coupling. The motors drive the pumps at 1100 RPM to supply 2 gallons of fuel per minute to each engine fuel system. The motor circuits are equipped with a plug and receptacle disconnect for quick replacement of either the fuel pump or motor as a unit.

506 **Fuel Pump Circuit** - Explanation The fuel pump circuit consists of two parts, control and power supply. Both circuits derive their power from the battery. The control circuit is used to energize the single fuel pump contactor operating coil. When the operating coil is energized, the relay responds to close three NO (normally open) contacts, which connect the fuel pump motors to the battery supply. The a-b and c-d contacts of the FPC are connected in parallel to a 15 ampere circuit breaker to the No. 1 fuel pump motor. The e-f contacts close to connect the No. 2 motor to the battery through a 15 ampere circuit breaker. The 30 ampere circuit breaker must be ON to energize the FPC and the 15 ampere circuit breakers must also be ON to operate the individual fuel pumps. This arrangement makes it possible to operate either No. 1 or No. 2 fuel pump separately if desirable. See Fig. 5-3, Schematic F.P. Circuit. No provision is made in the E9 "B" unit to operate the fuel pumps. An "A" unit should be connected by jumper cable to furnish control circuit.

507 **Engine Starting Circuit** The engine starting circuits consist of the engine start button switches, the starting contactors GS1 and GS2, the battery as a source of power and the starting windings in the main generator. This circuit converts the main generator into a powerful motor to crank the engine for starting.



Fuel Pump Circuit
Fig. 5-3

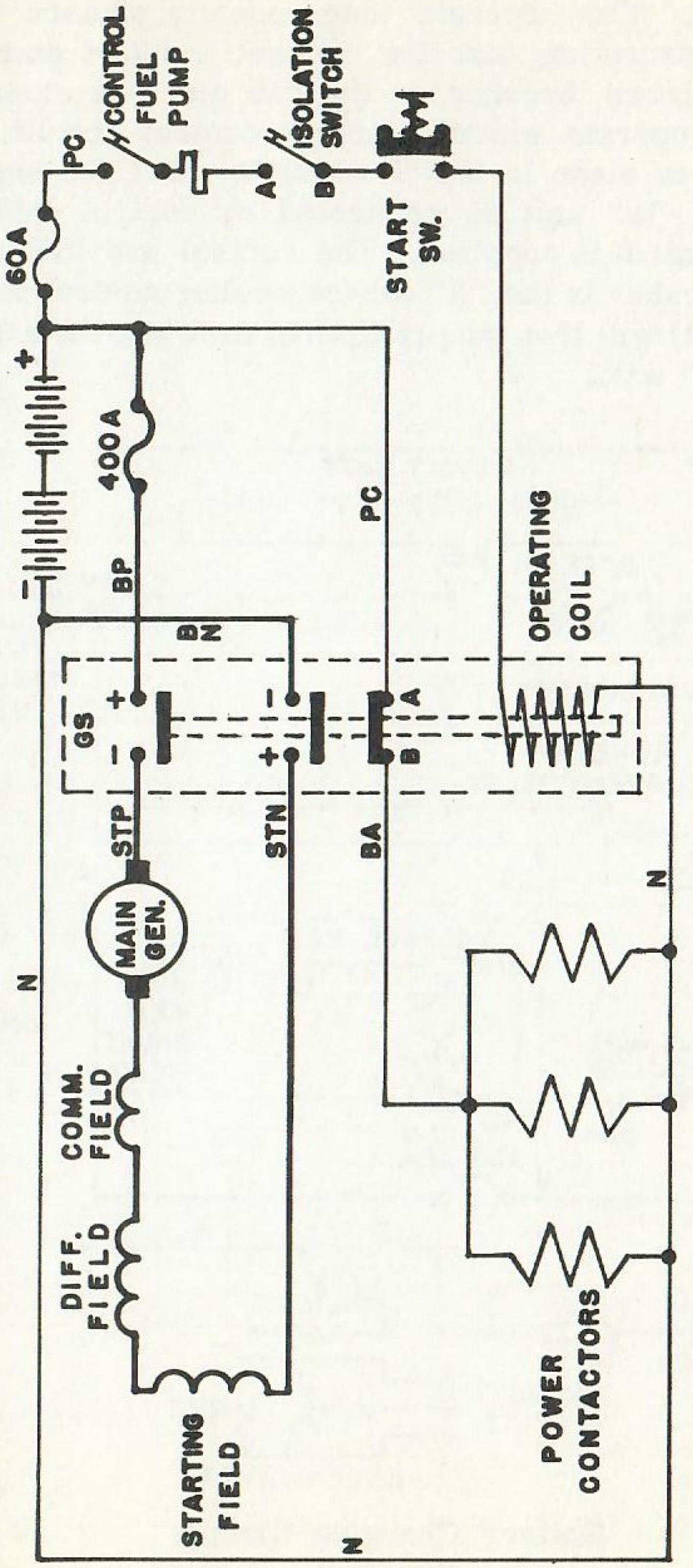

ELECTRO-MOTIVE DIVISION
GENERAL MOTORS CORP
LA GRANGE, ILL. U.S.A.
L.M.G.
VOLTS
74 V.D.C.
AMPS.
TYPE
SERIAL NO
MFD. BY
VAPOR HEATING CORP.
CHICAGO, ILL.
U.S.A.
THIS DEVICE HAS ALLOY CONTACTS. NEVER CLEAN, DRESS OR FILE.

Starting Contactor
Fig. 5-4

508 **Starting Contactors (GS1-GS2)** The starting contactors, Fig. 5-4, are mounted, one in each electrical cabinet: GS1 in the No. 1 cabinet and GS2 in the No. 2 cabinet. They are heavy duty contactors equipped with bridging type contact bars and protective NC interlocks which operate to open the transmission control circuit when the main contacts are closed. The operating coil is energized by pressing in the START button with the isolation switch in the START position.

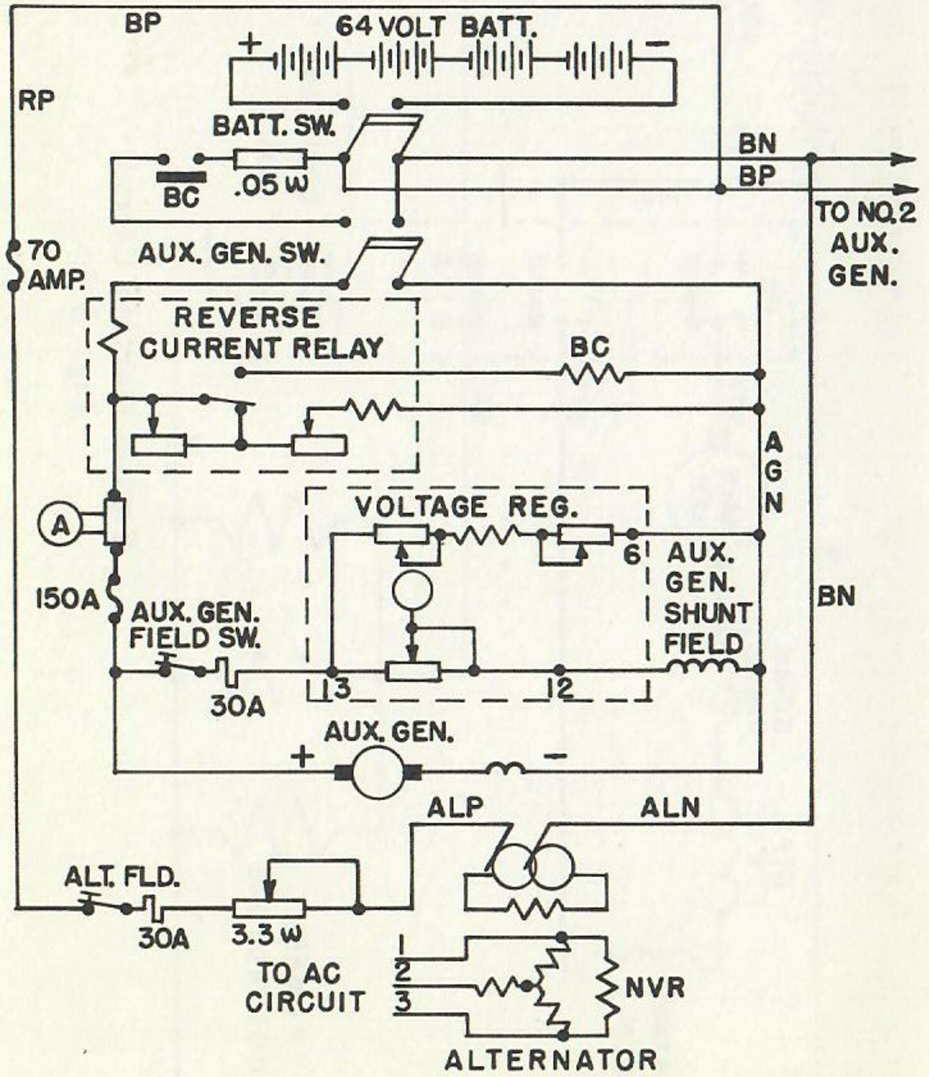
509 **Engine Starting Fuse** The 400 ampere main engine starting fuse is placed in the circuit to protect the main generator field windings from over-loading and damage during the engine starting period. In case the starting fuse is not in place, or is blown, the starting contactor GS will close when the start button is pressed, but the generator will not rotate the engine.

510 **Engine Starting Circuit** - Explanation The engine starting circuit, Fig. 5-5, is essentially two separate circuits. The control circuit is tapped off the PC wire through the isolation switch which must be in START position. When the START button is pressed, a circuit is completed to energize the GS operating coil. When energized, the GS contactor operates to connect battery to the main generator starting windings through the 400 ampere fuse. This connection causes the generator to "motor" and crank the engine. Each power plant in the E9 locomotive unit has its own starting


CONTROL FUEL PUMP
ISOLATION SWITCH
PC
A
B
START SW.
60A
+
-
400A
BP
PC
OPERATING COIL
BN
GS
+
-
A
B
STP
STN
BA
N
MAIN GEN.
N
COMM. FIELD
DIFF. FIELD
STARTING FIELD
POWER CONTACTORS
N

Engine Starting Circuit
Fig. 5-5

equipment. They operate independently of each other with the exception that the control and fuel pump 30 ampere circuit breaker in the cab must be closed in order to operate either starting control circuit. No provision is made in the "B" unit to start the engines unless an "A" unit is connected by control cable or hostler control is supplied. The control and fuel pump circuit breaker in the "A" cab (or hostler control station in "B" unit) will then supply control to crank the engines in the "B" unit.



Battery Charging Circuit
Fig. 5-6

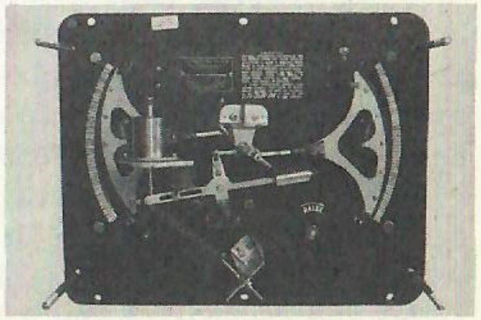
511 Auxiliary Generator And Battery Charging

Each power plant of the E9 unit is equipped with an auxiliary generator and the necessary equipment for charging the storage battery. The battery is common to the two power plants in each unit. The auxiliary generators are rated at 10 KW each and their charging rate is regulated by a voltage regulator. Reverse current relays RCR are also provided in each of the battery charging systems as are auxiliary generator field circuit breakers, battery charging contactors BC and 150 ampere charging fuses, Fig. 5-6.

512 Voltage Regulator Each power plant of the E9 unit is equipped with a voltage regulator located in the electrical cabinet. The voltage regulator functions to maintain an approximate 74 volt charging voltage as long as the engine is running regardless of the engine speed, Fig. 5-7.

513 Auxiliary Generator Field Circuit Breaker

A 30 ampere circuit breaker for each of the two power plants is provided to protect the auxiliary generator field winding against excessive current. These circuit breakers are located on the outside of the electrical cabinets. The No. 1 circuit breaker is located on the right hand side of the No. 1 electrical cabinet and the circuit breaker for the No. 2 auxiliary generator is located on the left hand side of the No. 2 cabinet. When a breaker trips to the OFF position, that auxiliary generator will not supply current to the low voltage system. The ammeter will show discharge and the alternator failure (no power) alarm will ring.



Voltage Regulator
Fig. 5-7

514 **Battery Ammeter** Both of the power plants in the E9 locomotive units are equipped with separate battery ammeters to indicate the amount of storage battery charge (or discharge) from each auxiliary generator. Under normal operating conditions, both ammeters show a slight charge. In case either ammeter shows discharge with engines running, check the 30 ampere auxiliary generator field circuit breaker or 150 ampere fuse.

515 **Reverse Current Relay (RCR)** In case the auxiliary generator output voltage should be lower than that of the battery voltage for any reason, the result would be for the battery current to flow to the auxiliary generator. This condition would cause the battery to attempt to motor the auxiliary generator with the subsequent depletion of the battery. The RCR will respond to a reverse flow of current to open the battery charging contactor (BC) thus preventing the above described condition and damage to either the battery or the auxiliary generator. Both battery charging systems of the E9 units have an RCR, Fig. 5-8.

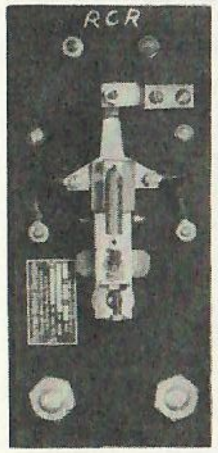
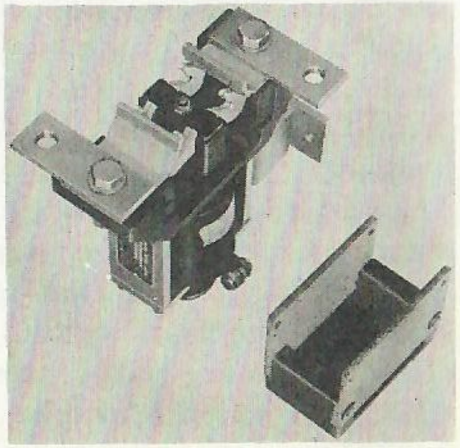


Fig. 5-8

516 **Battery Charging Contactor (BC)** The battery charging contactors are electrically operated switches which close to connect the auxiliary generator output to the low voltage system. Their position (closed or open contacts) is under the control of the reverse current relay RCR as explained in Art. 515.

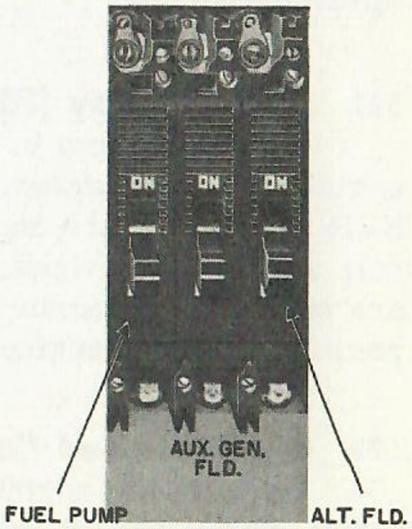


BC Contactor
Fig. 5-9

517 **Auxiliary Generator Fuse** (Battery Charging) Each auxiliary generator in the E9 locomotive unit has a 150 ampere fuse placed in the positive side of the charging circuit to protect the auxiliary generator against any possible overload. Should this fuse be open the battery ammeter will show discharge and the alternator "no power" alarm will operate to ring the alarm bell and light the blue light.

518 **Battery Charging Circuit** Two separate battery charging systems are used on the E9 locomotive, one for each power plant. They are connected in parallel so that either system will charge the battery if the other system is inoperative. However, continuous operation on one auxiliary generator is not recommended as these are 10 KW capacity generators. The additional load on the auxiliary generator of two control systems plus a steam generator as supplied on the E9 units will place a capacity loading on one auxiliary generator. In case one engine is shut down and isolated from the control system, this of course relieves the remaining auxiliary generator from the control system load. Both the battery switch and auxiliary generator switch at each power plant should be closed during normal operation. Both alternators will continue to operate from either auxiliary generator.

519 **Alternators And AC Circuits** The alternating current generators have battery excited field windings protected by 30 ampere circuit breakers, Fig. 5-10. The rotor windings are 3 phase "Y" connected, and the No Voltage Relay NVR is connected between phase



Circuit Breakers
Fig. 5-10

leads of the "Y." With the alternator operating properly, the NVR operating coil is energized and the NVR contacts a-b are closed to complete a circuit to the engine relay ER.

In case of an alternator failure on either power plant, the NVR is de-energized and the a-b interlocks open to de-energize the ER to the affected power plant. At the same time, the c-d contacts will close the alarm circuit and sound the alarm bell and light the blue alarm light at both power plants in the unit. Immediate action should be taken to correct the trouble as no cooling fans will operate on the affected power plant until alternating current is restored. The engine will idle and the main generator will not produce power to the traction motors. The locomotive unit will then operate at one half rated power.

520 **Engine Speed Control** The speed of the Diesel engine is controlled by the governor. The engineman, in order to regulate the speed and pulling power of the locomotive, changes the governor speed setting with the throttle. Both power plants in the E9 unit are controlled from the throttle lever in the cab, as are any additional units which might be connected in multiple control.

521 **Engine Relay (ER)** The ER relay controls the current supply to the A, B and C solenoids in the engine speed governor. The ground relay GR and the NVR interlocks are in the circuit to the ER operating coil as safety devices. If either of these interlocks are open, the governor will not respond to the throttle position and the engine speed will remain at idle.

522 **Engine Speed Control** - Explained The throttle lever at the engineman's controller has ten positions; STOP, IDLE and running speeds 1 through 8. The No. 1 throttle position does not increase engine speed and only closes the series "S" contactors, and

the shunt field and battery field contactors. This loads the generator and the locomotive will exert pulling power slowly and evenly. No. 2 through No. 8 throttle positions each will increase engine speeds 75 RPM as shown in the Engine Speed Chart, Fig. 5-11.

Movement of the throttle lever operates a drum type switch which connects the governor solenoids, A, B, C, and D, into the various combinations as illustrated in the Engine Speed Control Diagram. This diagram will show that the ER relay must be energized at all throttle positions, and also the "D" solenoid (DV) is not affected by the ER relay. This DV solenoid is such that its operation subtracts 150 RPM from the combination with which it is used. This occurs only in STOP - throttle 5 and throttle 6. To illustrate this, assume that the throttle is in No. 6, with all solenoids in the governor control energized, (A, B, C, and D). The idle speed is 275 RPM, the "A" solenoid adds 75 RPM, the "B" solenoid adds 300 RPM and the "C" solenoid adds 150 RPM. This would add up to 800 RPM in throttle 6 except that the "D" solenoid subtracts 150 RPM, leaving 650 RPM, which is the correct engine speed for No. 6 throttle position. Ground relay (GR) or control (PC) switch action in throttle 5 or 6 would de-energize the E relay, leaving only the "D" solenoid in the circuit and the engine affected would shut down. In other throttle positions the engine speed would be reduced to IDLE, 275 RPM.

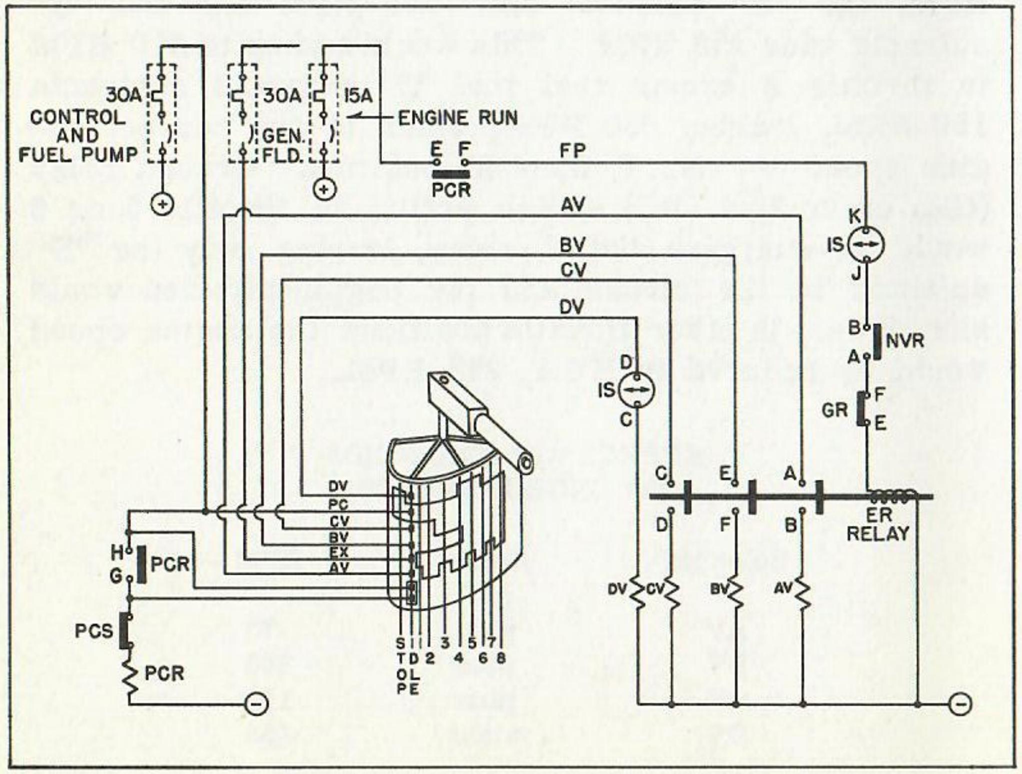
EFFECT OF SOLENOIDS
TO ENGINE SPEEDS

Solenoid	Action	RPM
AV	plus	75
BV	plus	300
CV	plus	150
DV	minus	150

NOTE: These figures are approximate due to the allowable tolerance in engine speed settings as shown in Fig. 5-11.

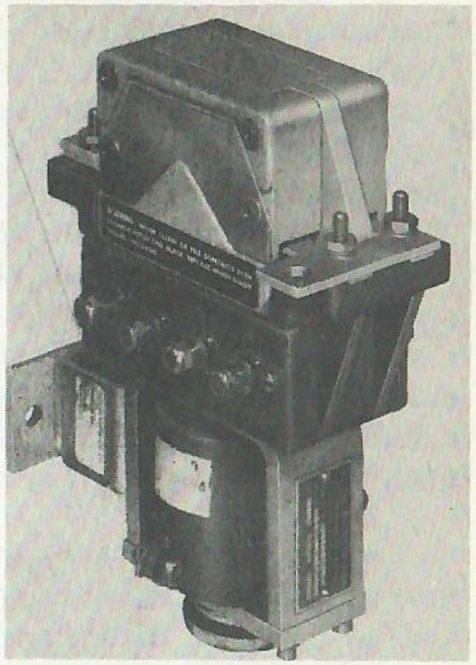
ENGINE SPEED CHART

Throttle Position	Governor Solenoids Energized A	B	C	D	Engine RPM Min.	Max.
Stop				*	0	0
Idle					275	283
1					275	283
2	*				339	369
3			*		414	444
4	*		*		500	508
5		*	*	*	564	598
6	*	*	*	*	650	658
7		*	*		725	733
8	*	*	*		800	808


30A
CONTROL AND FUEL PUMP
30A
GEN. FLD.
15A
ENGINE RUN
E F
PCR
FP
AV
BV
CV
DV
K
IS
J
B
NVR
A
D
IS
C
F
GR
E
C E A
D F B
ER RELAY
DV CV BV AV
DV PC CV BV EX AV
H
PCR
G
PCS
PCR
S T O P
I D L E
2 3 4 5 6 7 8

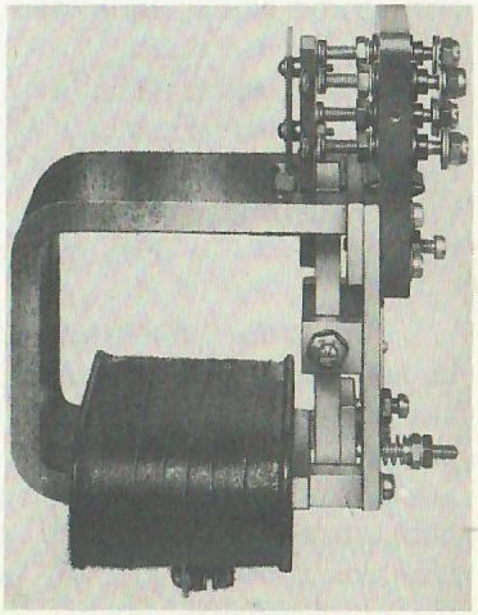
Engine Speed Control Circuit
Fig. 5-11

523 **Battery Field Contactor (BF)** When the throttle is moved from idle to Run 1, the BF contactors close and connect low voltage to the main generator battery fields for excitation. The battery field contactors remain closed as long as power is generated, opening during transition and wheel slip relay action, Fig. 5-12. A 70 ampere fuse is placed in the circuit to protect the field windings. This fuse is located on the distribution panel for each of the power plants and in case either fuse is defective, that power plant will not develop normal power.



BF Contactor
Fig. 5-12

524 **Wheel Slip Control** Two wheel slip relays are applied to each power plant in the E9 locomotive. WS1 and WS2 are mounted in the No. 1 electrical cabinet and are affected by the No. 1 and 2 traction motors, Fig. 5-13. WS4 and WS5 are mounted in the No. 2 electrical cabinet and are affected in their operation by the No. 3 and No. 4 traction motors. These are through cable type relays designed to protect the traction motors from



Wheel Slip Relay
Fig. 5-13

slipping in any transition stage, series, parallel or parallel-shunt. When operating in series, a balanced bridge circuit is established through four 2000 ohm resistors and connected to the magnet coil which is located on the yoke of the relay frame. In case either traction motor in the truck to which this circuit is connected should slip, the unbalanced electrical condition will energize the magnet coil. The relay contacts will close and sand will be applied by the action of the TDS time delay sanding relay.

When the locomotive is operating in parallel or parallel shunt transition, the WS relays are actuated by a current differential between the power cables which pass through the relay yoke.

These power cables are so arranged that the normal current flow through them is of equal magnitude, and in opposite directions. The magnetic field which is established by the current flowing in one power cable, is nullified by the magnetic field set up by the current flow in the other cable. In case one pair of wheels slip, a change in the amount of current flow exists in the power cable connected to that traction motor. This change in current flow results in an unbalancing of the magnetic fields. They are no longer equal in magnitude and the stronger field establishes a magnetic flux in the yoke actuating the contacts of the WS relay. Automatic sanding occurs for approximately 20 seconds as a function of the TDS relay in parallel and series only.

In order to obtain adequate wheel slip protection in high locomotive speed operation, it became necessary to use an additional through cable type relay per power plant. During parallel and parallel shunt operation, basically the wheel slip relays will recognize an unbalanced condition of current flowing through the traction motors. At the higher locomotive speeds with the consequently lower current values, this system in itself becomes progressively less sensitive in its ability

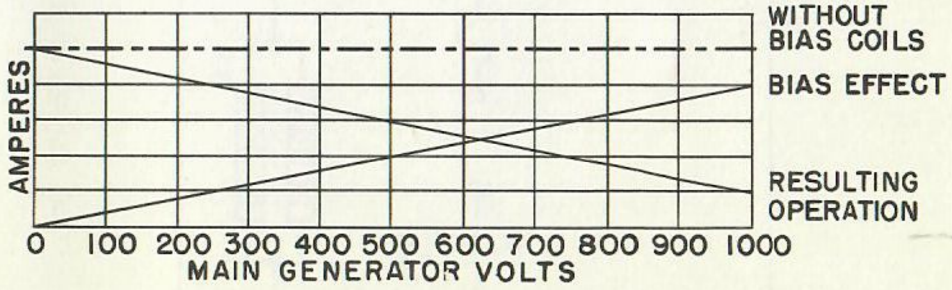
to detect wheel slipping. To correct this condition, the relays are made more sensitive by providing a circuit through the relay coils during parallel and parallel shunt operation. This circuit in effect, provides a biasing to the relay which is proportional to the main generator voltage. The biasing effect is opposite in each of the two relays per power plant so that wheel slips in either traction motor in that power truck will be recognized. The bias circuit connects the wheel slip relay coils in series with an adjustable resistance of 70,000 ohms across the main generator voltage during parallel or parallel shunt operation.

Series - BF Contactor Opens
- SH Relay Closes
- Sanding Occurs

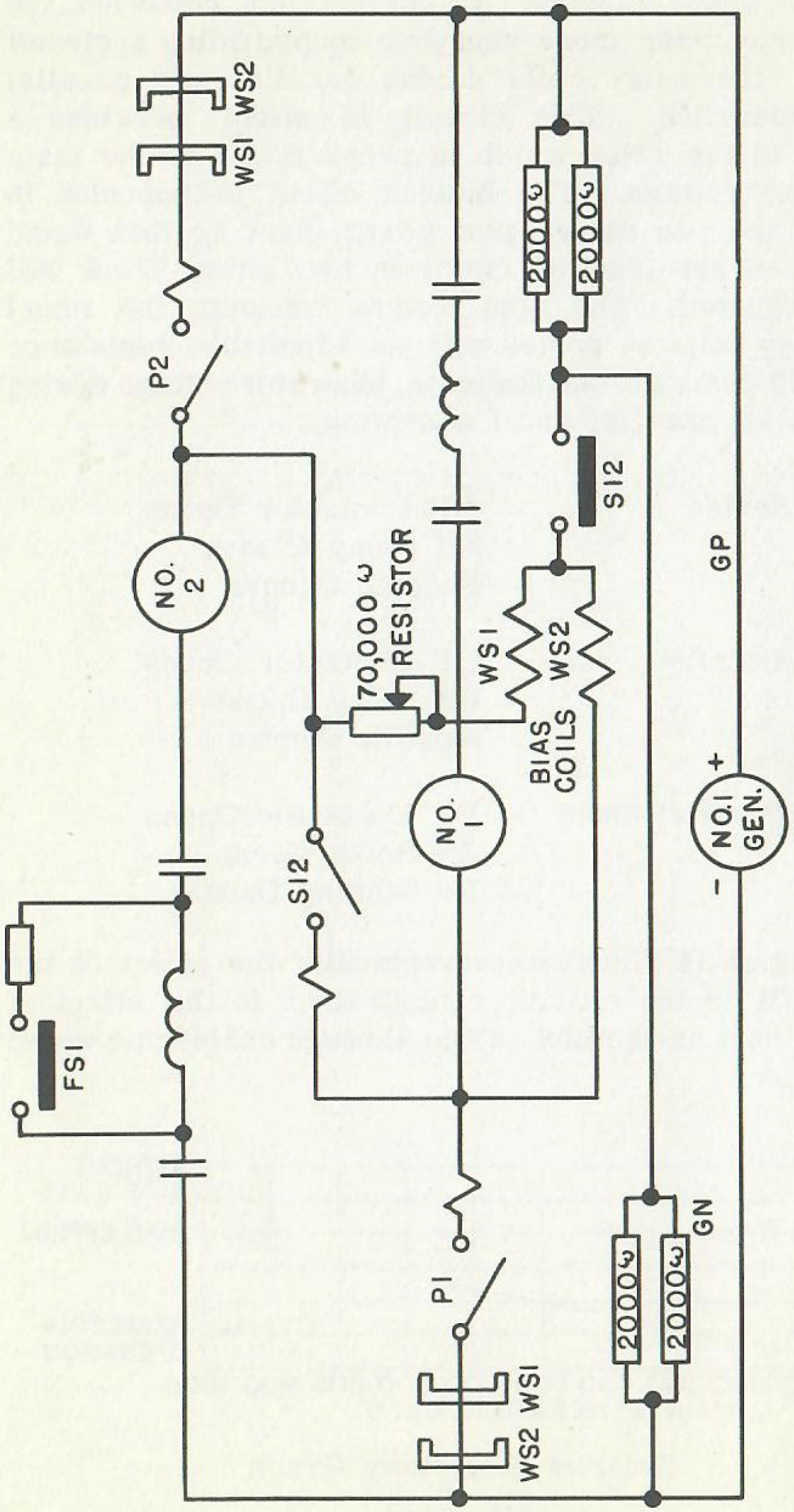
Parallel - BF Contactor Opens
- SH Relay Opens
- Sanding Occurs

Parallel Shunt - BF Contactor Opens
- SH Relay Opens
- No Sanding Occurs

Fig. 5-14 illustrates graphically the effect of the bias coils in the circuit, comparative to the effect of current only as applied to the through cable type wheel slip relay.



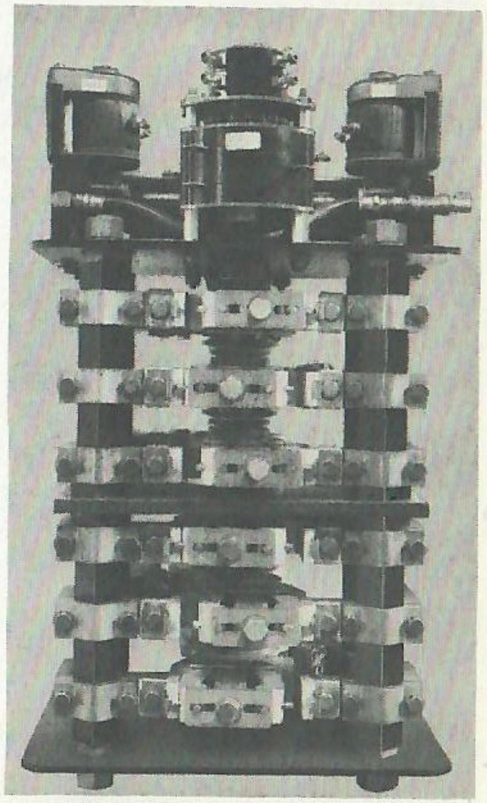
Relative Sensitivity Graph
Fig. 5-14



High Speed Wheel Slip Circuit
Fig. 5-15

A schematic diagram, Fig. 5-15, illustrates the high speed wheel slip protective circuit as applied to the No. 1 power plant. The No. 2 power plant of the E9 locomotive is identical in this respect and each is entirely independent from the other in its operation.

525 **Dynamic Brake Operation** The effect of the dynamic brake is very similar to that of the independent air brake on the locomotive. The load indicating meter can be used in the same manner as the independent air gauge, as it will indicate the current in amperes generated by the traction motors, as compared with the air pressure indicated on the air gauge. In order to obtain the conditions necessary for dynamic braking operation on locomotives equipped with that feature, the traction motor connections must be changed to convert the motors into electrical generators. By movement of the selector handle on the engineman's control stand, to the position showing the letter "B," the brake transfer switches (BKT) Fig. 5-16, are moved to a position whereby circuits are established which will make this conversion. With the BKT switch (cam switch) in the braking position, and the traction motors converted to generators, the trailing load connected to the locomotive is now pushing the locomotive. As power is necessary to turn the armatures of the "generators" and as they are geared to the locomotive wheels, a



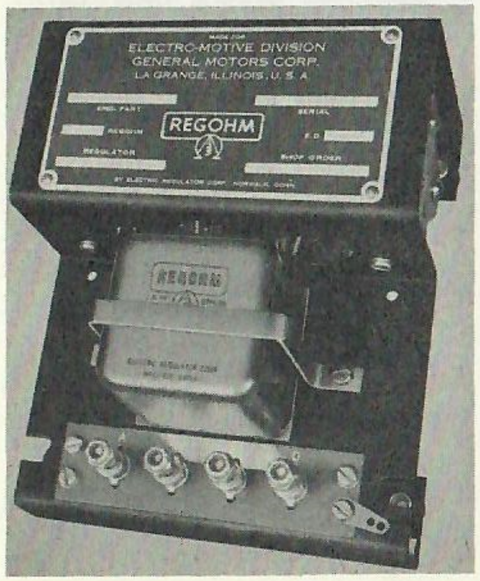
Brake Transfer Switch
Fig. 5-16

holding action is developed and the speed is retarded.

By moving the dynamic brake control lever to the right, the load indicating meter pointer moves to indicate that the traction motors are generating more amperage. This is the result of increasing the field excitation of the traction motors and causes an increase in the braking effort of the locomotive.

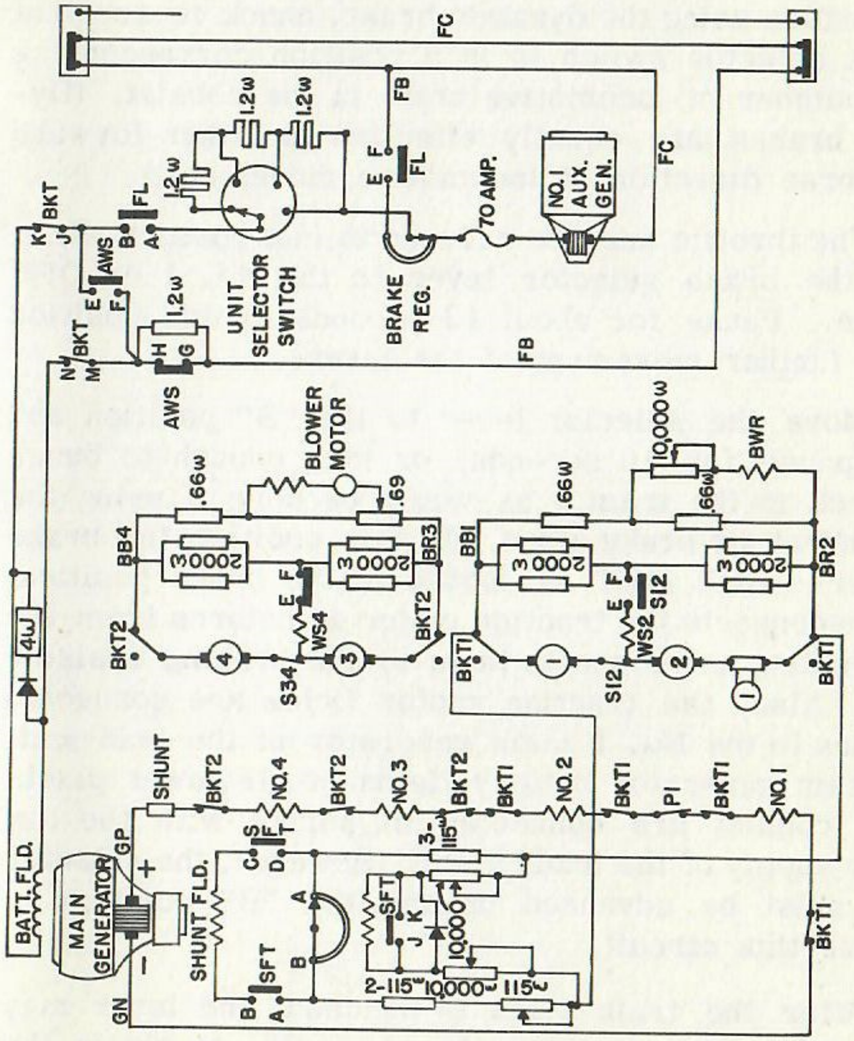
The density of the magnetic field set up between the field poles and the rotating armature of the traction motors determines the amount of braking effect produced. The density of this magnetic field is controlled by the engineman, by positioning the dynamic brake control lever. However, this magnetic density (or flux) is limited in its strength to produce a maximum of 700 amperes at the braking grids by a dynamic brake regulator, Fig. 5-17.

The No. 1 main generator battery field is connected in series with the low voltage supply; movement of the dynamic brake lever in the cab controls the excitation of the No. 2 main generator. In multiple unit control, the dynamic brake jumper cables must be in place between all units in the consist. With the jumper cables in place, all units will operate in unison and full efficiency will be obtained for dynamic braking. Fig. 5-18 is a schematic of the dynamic brake circuit.


MADE FOR
ELECTRO-MOTIVE DIVISION
GENERAL MOTORS CORP.
LA GRANGE, ILLINOIS, U.S.A.
REGOHM
REGOHM

Dynamic Brake Regulator
Fig. 5-17

The dynamic brake grids are located in the grid-hatch portions in the top of the carbody. Blower


FC
FB
FC
1.2w
1.2w
1.2w
70 AMP.
NO.1 AUX. GEN.
BRAKE REG.
UNIT SELECTOR SWITCH
BKT
AWS
FL
BLOWER MOTOR
10,000w
BWR
.66w
.69
.66w
.66w
3000
2000
BB4
BR3
BB1
BR2
BKT2
BKT1
S34
WS4
WS2
S12
SHUNT
NO.4
NO.3
NO.2
PI
NO.1
BATT. FLD.
MAIN GENERATOR
GP
GN
SHUNT FLD.
SFT
2-115Ω
10000Ω
115Ω
4WJ

Schematic Of Dynamic Brake Circuit
Fig. 5-18

fans are located above the grids and operate to dissipate the heat generated in the resistor grids, using some of the power generated by the traction motors to drive the fan motor.

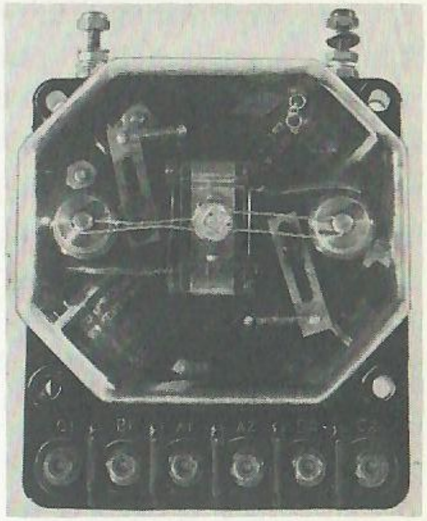
To operate the dynamic brakes on locomotives so equipped, proceed as follows:

Before using the dynamic brake, check to see that the unit selector switch is in a position corresponding to the number of locomotive units in the consist. (Dynamic brakes are equally effective in either forward or reverse direction of locomotive movement.)

The throttle must be reduced to idle position, then, move the brake selector lever to the No. 1 or OFF position. Pause for about 10 seconds in this position before further movement of the lever.

Move the selector lever to the "B" position and again pause for 10 seconds, or long enough to bunch the slack in the train - as would be done if using the independent air brake alone. In this position the brake transfer switch BKT is moved to the brake position. This disconnects the traction motor armatures from the field winding and connects them to the braking resistor grids. Also, the traction motor fields are connected in series to the No. 1 main generator in the lead unit. The main generator battery fields of all power plants in the consist are connected in series with the low voltage supply of the leading unit. However, the selector lever must be advanced beyond the "B" position to energize this circuit.

After the train slack is bunched, the lever may be moved further to the right gradually, to obtain the desired braking effort. Observe the load indicating meter pointer as the lever is advanced. If full braking effort is desired, the lever may be advanced to the full "B" position, and permit the regulator to maintain the maximum 700 amperes. The lever should always be advanced slowly to prevent a sudden surge of current beyond the point where the regulator will limit the current at 700 amperes. In case that the limit is exceeded, the brake warning relay (BWR) will pick up and the warning light will flash on. Normally, the regulator will prevent an occurence of this type, but should it happen, allow a little time for the regulator to function before moving the hand lever. If the warning light does not go out through the automatic function of the regulator within 15 seconds, the lever should be moved to reduce the braking effort until the light is extinguished.



Brake Warning Relay
Fig. 5-19

When necessary, the automatic brakes may be used in conjunction with the dynamic brakes, but care must be used to keep the independent locomotive brakes FULLY RELEASED. The resulting braking effort of the combination of dynamic and independent air brakes will cause the locomotive wheels to slide.

As the locomotive speed is reduced to approximately 10 miles per hour, the dynamic brakes are less effective, and it may be desirable to use the independent air to complete the stop. This may be accomplished by releasing the dynamic brake completely, placing the lever in OFF, and making an application of independent air great enough to compensate for the released dynamic brake. This application of independent air brake will normally be about 10 pounds, but will vary with road and train conditions.

However, the changeover should be smooth and should be done simultaneously to prevent slack action between the locomotive and train.

The most effective dynamic braking is between 20 and 30 miles per hour, depending on gear ratio.

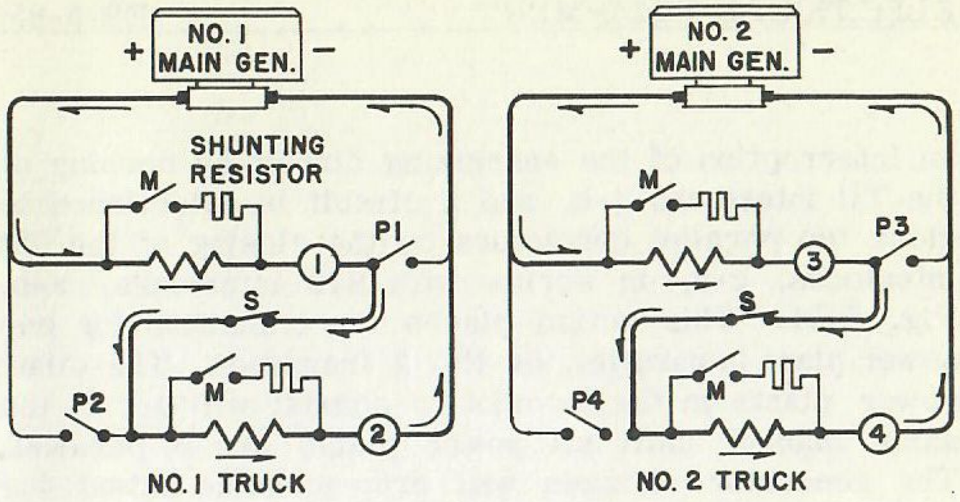
The E9 locomotive units can be operated in dynamic braking with older units that are not equipped with current limiting regulators, if all of the units are of the same gear ratio. The "A" unit having the lowest maximum braking current rating should be placed as the lead unit in the consist. The engineman can then operate and control the braking effort up to the limit of that unit without overloading the dynamic brake system.

526 **Transition Control Circuits** The sequence of transition on the E9 locomotive is automatic in all forward transition stages, and in backward steps from 3 to 2. Transition from 2 to 1 must be made by reducing the throttle to idle position.

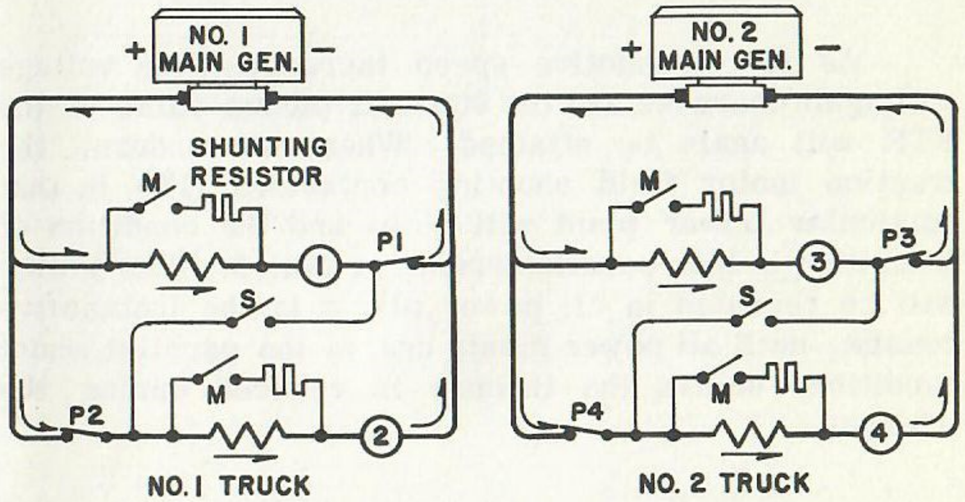
With the transition lever in No. 1, the reverser handle in a position for locomotive movement, and the throttle in No. 1 position, the electrical equipment operates to establish the circuits necessary to move the locomotive, but does not increase engine speeds. S12 contactors in the No. 1 electrical cabinets and S23 contactors in the No. 2 electrical cabinets close, connecting the main generators to their traction motors, in series. The battery field and shunt field contactors close to energize the main generator fields.

Power is generated and transmitted to the traction motors, but is limited by the idling speed of the engine. Further advance of the throttle up to No. 8 position, increases engine speed as illustrated in the Engine Speed Chart, Fig. 5-11. The increase in engine speeds results in a proportional increase in electrical power to turn the traction motor armatures until such time as 900 volts (approximately) generator output is reached.

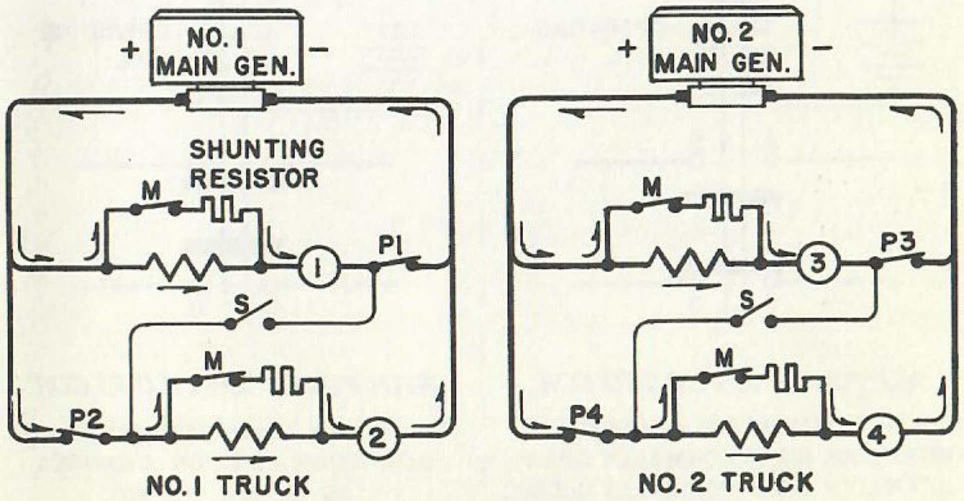
With the throttle in No. 8 position, and 900 volts generator output, the FTR (Forward Transition Relay) will pick up, closing the normally open interlocks c-d, and opening the normally closed interlocks, a-b. (See schematic wiring diagram for circuits.) Transition Relay TR is thus energized closing the holding interlocks, a-b. S12 contacts are caused to open due to


+
NO. 1
MAIN GEN.
−
SHUNTING
RESISTOR
M
P1
1
S
P2
M
2
NO. 1 TRUCK
+
NO. 2
MAIN GEN.
−
M
P3
3
S
P4
M
4
NO. 2 TRUCK

SERIES - NO. 1 TRANSITION


+
NO. 1
MAIN GEN.
−
SHUNTING
RESISTOR
M
P1
1
S
M
P2
2
NO. 1 TRUCK
+
NO. 2
MAIN GEN.
−
M
P3
3
S
M
P4
4
NO. 2 TRUCK

PARALLEL - NO. 2 TRANSITION

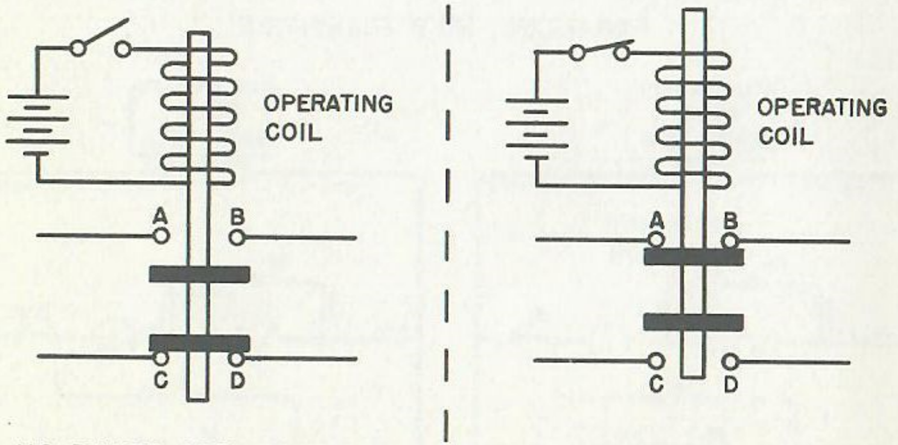

+
NO. 1
MAIN GEN.
−
SHUNTING
RESISTOR
M
P1
1
S
M
P2
2
NO. 1 TRUCK
+
NO. 2
MAIN GEN.
−
M
P3
3
S
M
P4
4
NO. 2 TRUCK

PARALLEL SHUNT - NO. 3 TRANSITION

High Voltage Circuit
Fig. 5-20

an interruption of the energizing circuit by opening of the TR interlocks j-k, and a circuit is established to close the parallel contactors by the closing of the TR interlocks, c-d, in series with S12 interlocks, a-b. Fig. 5-21. This action places the transition for one power plant in parallel, or No. 2 transition. The other power plants in the locomotive consist will act in the same manner until all power plants are in parallel. The generator voltages will drop to some extent due to the change in traction motor connections from series to parallel.

As the locomotive speed increases, the voltage will again increase and the 900 volt pickup value of the FTR will again be attained. When this occurs, the traction motor field shunting contactors (FS) in that particular power plant will close and the condition of transition is then parallel-shunt, or No. 3. This action will be repeated in all power plants in the locomotive consist, until all power plants are in the parallel shunt condition, unless the throttle is reduced during the interval.



NO POWER APPLIED TO COIL

COIL IS DE-ENERGIZED (DROPPED OUT)
INTERLOCK AB IS NORMALLY OPEN
INTERLOCK CD IS NORMALLY CLOSED

WITH POWER APPLIED TO COIL

COIL IS NOW ENERGIZED (PICKED UP)
INTERLOCK POSITION CHANGE:
AB IS NOW CLOSED
CD IS NOW OPENED

Operation Of Interlock
Fig. 5-21

In order to prevent cycling of transition due to the voltage drop immediately following forward transition steps, time delay relays are used in the control circuits. The time delay relay (TD) interlocks are connected into the power circuits in a manner which will lower the pickup value of the FTR following transition, to a point where it will not drop out with the decrease in voltage, for approximately 10 seconds. Refer to schematic wiring diagram for value of resistors inserted into the circuit during delay interval.

This time delay is adequate to permit the generator voltage to return to normal, thus preventing cycling from one transition step to another.

Backward transition from parallel shunt to parallel is automatic, and is accomplished by the functioning of the FTR. Following the action of the FSD field shunting delay relay, the inherent dropout value of FTR is restored (500 to 550 volts). When the current value rises to a point where the voltage drops to this inherent dropout value, the FTR opens. This action de-energizes the field shunting contactor operating coil, FS, and drops out the FS contacts, placing the transition back into the straight parallel condition of transition, No. 2. This action is repeated throughout all power plants in the locomotive consist, until all are in parallel. The inherent electrical characteristics of each power plant differ from each other to the extent that normally transition will not occur on any two power plants simultaneously. This method of making each power plant independent from the others results in smooth train operation from one stage of transition to another.

Backward transition from parallel to series is dependent upon the engineman entirely, and can only be accomplished by closing the throttle to idle. If desirable, depending upon conditions, the throttle may then be advanced to any point and the condition of transition will remain in series until the foregoing sequence of events is repeated.

When making a complete stop with the E9 locomotive, it is very important that the throttle is closed to IDLE before the stop is made. If the throttle is not completely closed to IDLE, the electrical equipment will not be disconnected and the traction motors will continue to exert pulling force against the brakes. This may result in damage to the electrical equipment while standing with brakes set and power applied.

SECTION 6

STEAM GENERATOR

OK-4740, OK-4635, OK-4630, OK-4625, AND OK-4616

INTRODUCTION

The instructions contained in this section are for the guidance of personnel engaged in the operation of OK series steam generators. A general description of the steam generator is given, the operating technique is outlined and a trouble shooting section is provided for the operator.

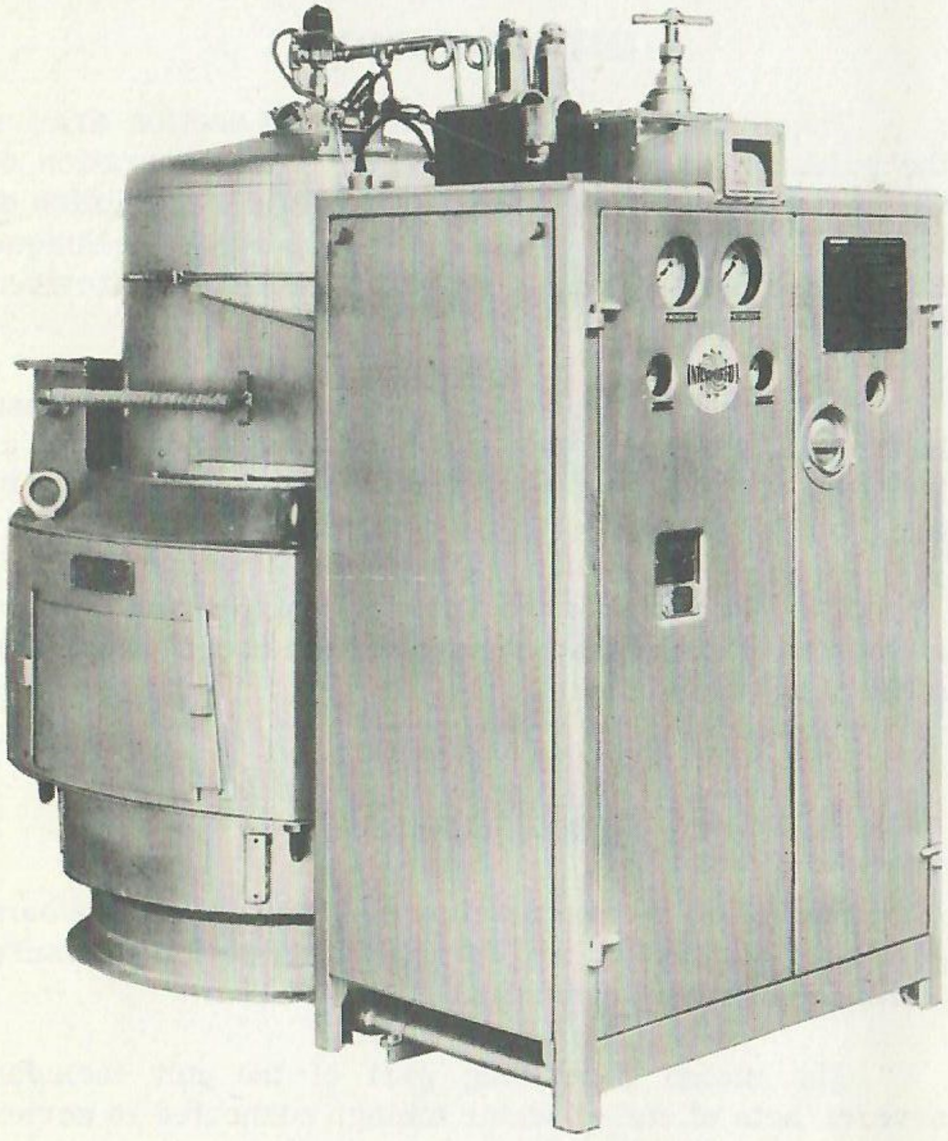
The symbol number after each device mentioned in the text refers to the schematic operating chart at the end of this section. The numbers are used to facilitate identification of the various devices.

The chart shows the various controls and devices on the OK series steam generator and outlines the flow of fuel, water and steam.

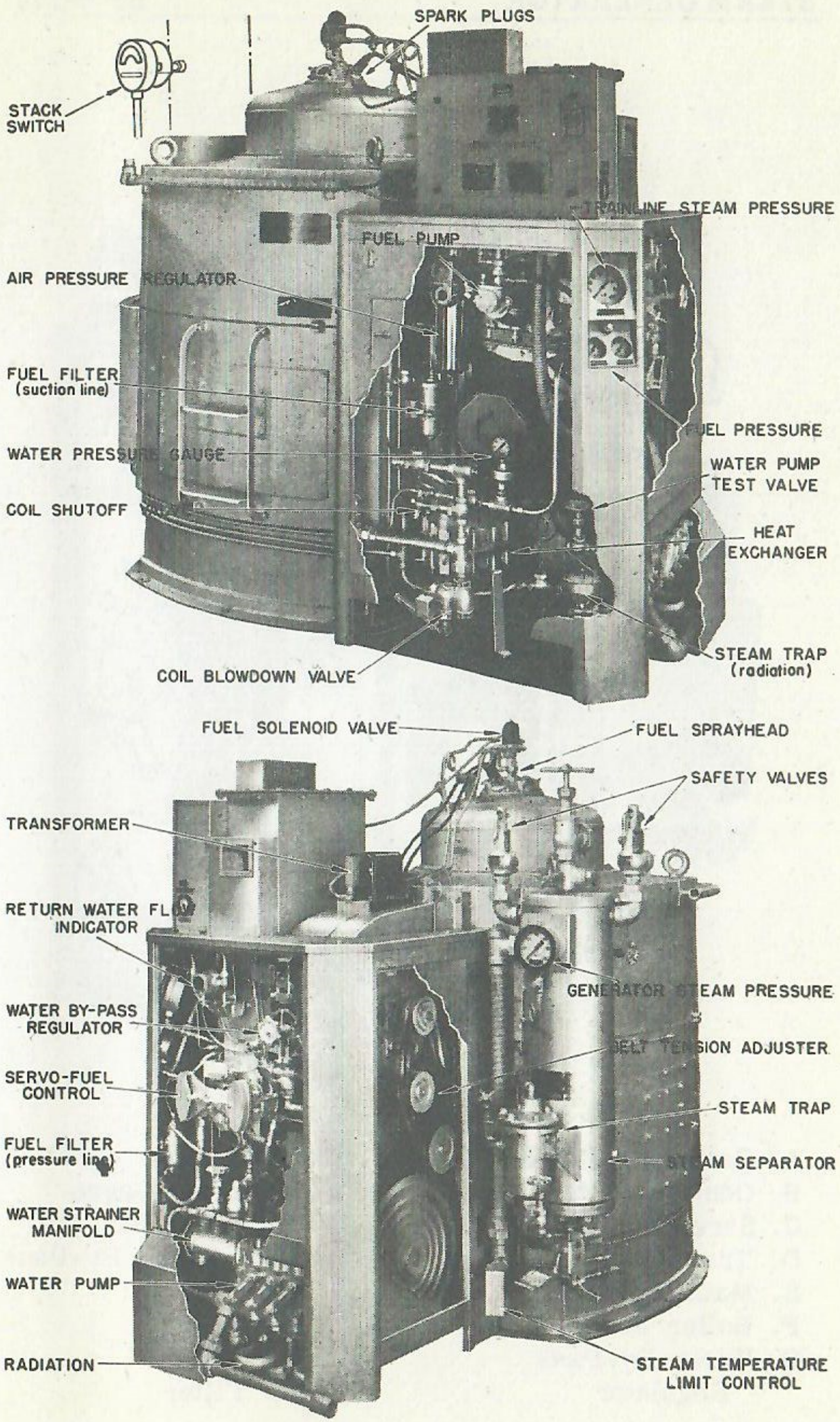
DESCRIPTION

Operation is completely automatic after the steam generator is started, and full operating steam pressure is reached within a few minutes.

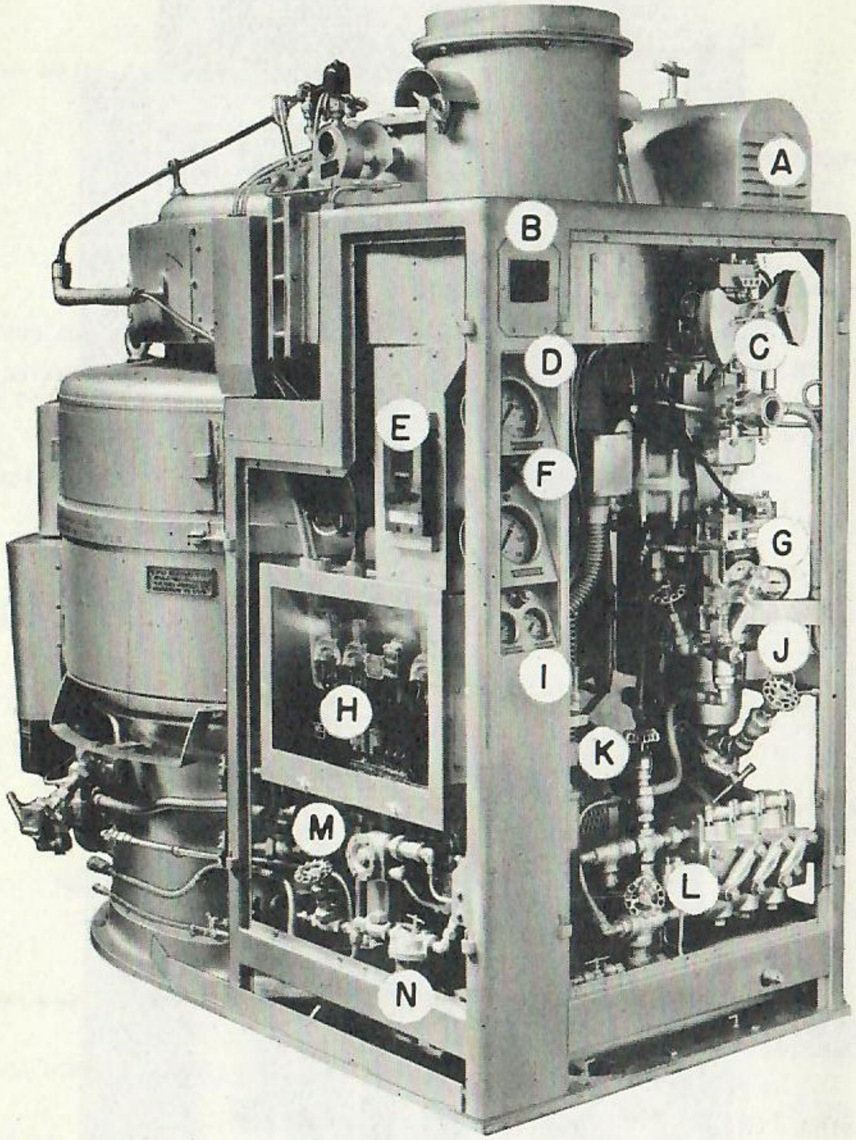
The steam generating part of the unit includes several sets of coiled water tubing, connected in series to form a single tube several hundred feet long. Feed water, after passing through the heat exchanger, goes through the economizer coil and from there to the main coils of the steam generator. As the water progresses through the coils it is converted into steam. Heat is furnished by the combustion of diesel fuel oil, which is sprayed by compressed air through the atom-



OK-4625 Vapor-Clarkson Steam Generator
Fig. 6-1a


SPARK PLUGS
STACK SWITCH
TRAINLINE STEAM PRESSURE
FUEL PUMP
AIR PRESSURE REGULATOR
FUEL FILTER (suction line)
FUEL PRESSURE
WATER PRESSURE GAUGE
WATER PUMP TEST VALVE
COIL SHUTOFF VALVE
HEAT EXCHANGER
STEAM TRAP (radiation)
COIL BLOWDOWN VALVE
FUEL SOLENOID VALVE
FUEL SPRAYHEAD
SAFETY VALVES
TRANSFORMER
RETURN WATER FLOW INDICATOR
GENERATOR STEAM PRESSURE
WATER BY-PASS REGULATOR
BELT TENSION ADJUSTER
SERVO-FUEL CONTROL
STEAM TRAP
FUEL FILTER (pressure line)
STEAM SEPARATOR
WATER STRAINER MANIFOLD
WATER PUMP
RADIATION
STEAM TEMPERATURE LIMIT CONTROL

OK-4630 Vapor-Clarkson Steam Generator
Fig. 6-1b



A. Converter Housing
B. Control Switch
C. Servo Fuel Control
D. Trainline Press. Gage
E. Main Switch
F. Boiler Press. Gage
G. Water By-Pass Regulator
H. Control Panel
I. Fuel Press. Gages
J. Fill Test Valve
K. Manual Water By-Pass Valve
L. Water Pump
M. Fuel Pump
N. Fuel Filter

OK-4740 Vapor-Clarkson Steam Generator
Fig. 6-1c

izing nozzle in the fuel spray head-105 into the firepot above the coils. Here the fine oil spray mixes with air supplied by the blower-202, and is ignited by a continuous electric spark-220. The hot gases flow, first downward, then up and outward through the coils, finally flowing out the stack.

The supply of fuel is regulated to evaporate approximately 90% of the water pumped through the coils. The excess water flushes scale and sludge from the coils and is carried over with the steam into the steam separator-221, where the water and sludge are separated from the steam.

The excess water collects in the bottom of the steam separator. Water above the level of the return outlet flows out through a steam trap-223 and through the heat exchanger-213, where it gives up its heat to the incoming feed water. From the heat exchanger the return water flows through return water flow indicator-218 back to the water supply tank-232.

The motor converter-215 drives the blower-202, water pump-230 and fuel pump-209 at a constant speed. The water by-pass regulator-111 automatically controls steam generator output by regulating the amount of water fed to the coils. Before entering the coils, the water passes through servo-fuel control-108, which admits fuel to the spray nozzle in direct proportion to the amount of water entering the coils. The servo-fuel control also adjusts the damper-203 to admit the proper amount of air for proper combustion of the fuel.

The trainline steam pressure is regulated by adjusting the setting of the water by-pass regulator-111. The length of train and the weather conditions determine the setting.

BEFORE STARTING

The valves designated by odd numbers must be OPEN during normal operation of the steam generator. Valves designated by even numbers must be CLOSED during normal operation of the steam generator. Normally open valves are fitted with a cross type handle; normally closed valves are fitted with the standard round handle.

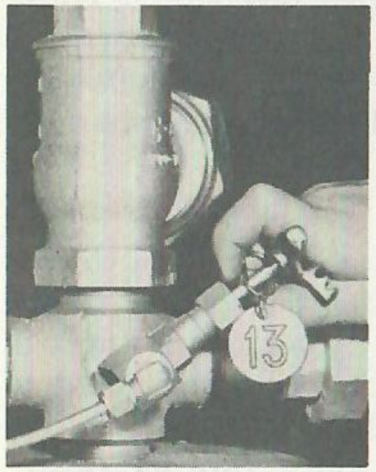
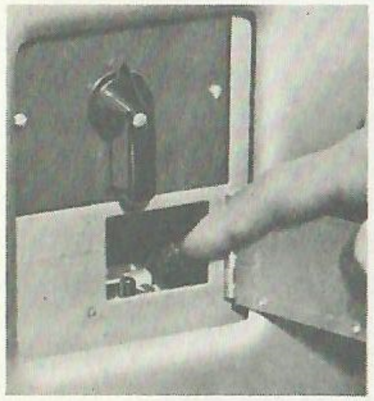


Fig. 6-2

1. Make certain that the following valves are OPEN:

   Atomizing Air Shutoff Valve-1
   Coil Shutoff Valve-3
   Return Water Outlet Valve-9
   Trainline Cross-Over Valve-11
   Steam Admission Valve-13 to Water By-Pass Regulator-11
   Three-Way Washout Valve-17
   Water By-Pass Regulator Shutoff Valve-19
   Water Supply Stop Valve-21



Overload Reset
On OK-4625
Fig. 6-3

2. Be sure that the following valves are CLOSED:

   Coil Blowdown Valve-2
   Layover Connection Shutoff Valve-6
   Manual Water By-Pass Valve-8
   Return Line Valve (Standby)-56
   Steam Admission Valve-10 to Radiation-217 (open in cold weather operation).
   Washout Inlet Valves-14-16
   Water Pump Test Valve-18
   Water Drain Valves-20 and 22

3. Both overload reset button-106 and stack switch-109 reset button must be "In." The overload reset button is located on the magnetic overload relay, Fig. 6-3.

TO FILL

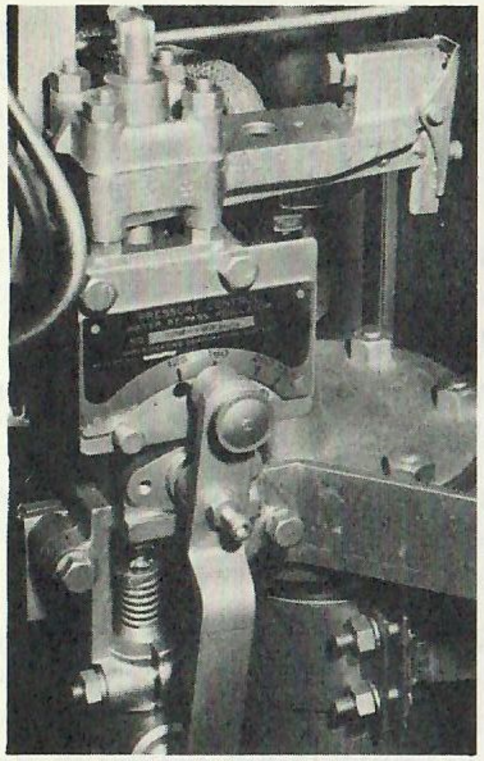
1. Open the atomizing air shutoff valve-1 and fill-test valve-4; latch open the separator blowdown valve-12 to drain the steam separator. Close the separator blowdown valve when the separator is completely drained.
2. Close the main switch and turn the control switch-102 to FILL. If the coils are empty it will take about five minutes to fill the steam generator with water.
3. While the coils are filling see that spark-220 is available for ignition. Check ALL valves.
4. When water discharges from the fill-test valve-4 turn the control switch-102 to OFF and close the fill-test valve.

NOTE: The water pump, being a high pressure pump will apply an undesirable hydrostatic pressure to the steam generator, gauges and controls, unless the control switch is immediately placed in the OFF position when water discharges from the fill-test valve.

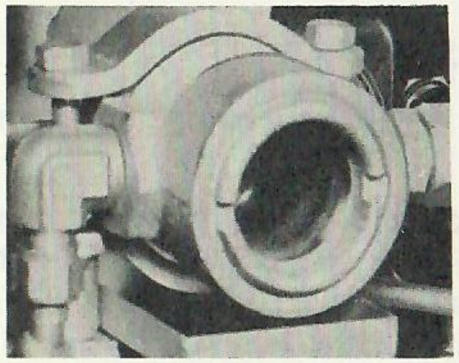
TO START

CAUTION: Do not start the steam generator unless the coils are filled.

1. Latch open the separator blowdown valve-12 and turn the control switch-102 to RUN. (For easy starting, be sure the control switch has been OFF long enough for the motor to come to a full stop.)
2. Close the separator blowdown valve-12 when the generator steam pressure gauge-212 registers approximately 150 pounds.
3. OPEN THE SEPARATOR BLOWDOWN VALVE SEVERAL TIMES FOR THREE TO FIVE SECOND INTERVALS DURING THE FIRST FEW MINUTES OF OPERATION.



Water By-Pass Regulator
Fig. 6-4



Return Water
Flow Indicator
Fig. 6-5

4. Set the water by-pass regulator-111, Fig. 6-4, to the required trainline pressure.
5. After the trainline is coupled, open the remote control trainline shutoff valve-7 (if used) by depressing the reset lever-7a. Then slowly open the trainline stop (shutoff) valve-15.

NOTES:

1. Check the return water flow after the steam generator has settled down to a steady output. The return flow water indicator-218, Fig. 6-5, should cycle from 4 to 12 times a minute on 3000 lb. units; from 4 to 10 times a minute on 2500 lb. units, and from 4 to 8 times a minute on 1600 lb. units.
2. If the steam generator does not start or function properly, check all valves to see that they are open or closed as indicated in the operation chart.
3. The steam generator should come up to full operating pressure in 2 or 3 minutes. It may take 10 to 15 minutes to build up the required operating steam pressure in the trainline, depending upon train length and trainline condition.

STANDBY HEATING
(If Used)

Standby heating is applied to the locomotives to prevent freeze-up of the steam generator and its water supply tank at times when the steam generator is not required to make steam. In brief, the generator operates with an amount of fuel sufficient to heat the water but not to make steam, and circulates this hot water through the generator and supply tank.

When the control is switched to "Standby," the unit operates at low fire under control of an aquastat with full circulation of water through the coils, cycling "on" when the water temperature drops to 100°F., and cycling "off" at 135° F. During the "off" cycle the warm water is circulated through the system by a small circulating pump.

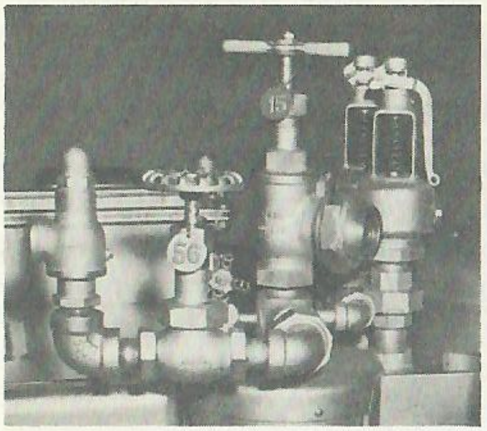
Low fire operation on "Standby" is obtained through the automatic burner adjusting control and the three-way solenoid valve. The burner control has a spring-loaded, hydraulic piston mechanism which controls the position of the metering pin in the servo. During normal operation, fuel pressure against this piston holds the metering pin up in its operating position.

On "Standby" the solenoid valve relieves the fuel pressure on the piston; spring tension then forces the piston down and holds the metering pin below its normal operating position, thus changing the delivery ratio of water to fuel and combustion air. Maximum water flow is maintained, but air and fuel flow into the combustion chamber is reduced to low-fire proportions.

Standby Operation:

1. Set the water by-pass regulator-111 for maximum pressure.

2. Close the stop-check valve-15.



Valves 56 and 15
Fig. 6-6

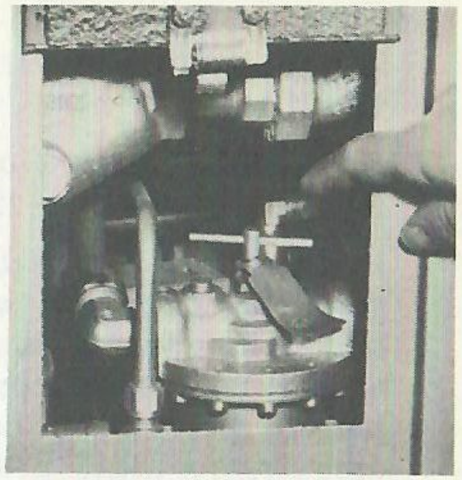
3. Close steam trainline pressure gauge line valve-11.
4. Open standby water return line valve-56 located at top of steam separator below stop-check valve-15, Fig. 6-6.
5. Open the radiation heating valve-10 and the layover connection shutoff valve-6 to allow the heated water to flow through the protective heating system.
6. Turn the Control switch-102 to "Standby" position.

Return To Normal Operation:

1. Close standby return line valve-56, radiation heating valve-10 (open in cold weather operation), and layover connection shutoff valve-6.
2. Open the separator foot valve and drain excess water from boiler coils, following the normal procedure for firing a boiler.
3. Place the control switch in "Run" position. When steam pressure reaches 150 psi, close separator foot valve, open stop-check valve-15.
4. Set water by-pass regulator at desired pressure.
5. Open steam trainline pressure gauge valve-11.

RUNNING ATTENTION

1. Open the separator blowdown valve-12 at least once every hour. (Except when in standby operation, if used). Frequent blowdowns will reduce the tendency for sludge to accumulate.



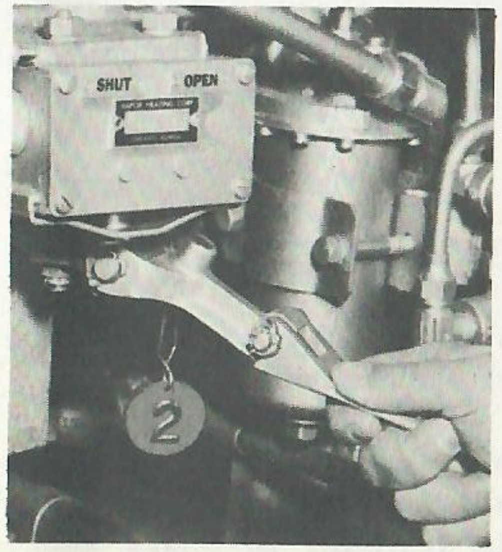
Suction Line Fuel Filter
Fig. 6-7

2. Turn the handle on the fuel filter-206, Fig. 6-7, during stops. At the same time, turn the handle on the treatment injector filter-225, where this method of water treatment is used.

CAUTION: Trainline remote control valve-7 (when used) and/or stop and check valve-15 must be closed when shutting off trainline steam.

TO SHUT DOWN THE STEAM GENERATOR

For short stops it is only necessary to close the stop and check valve-15. The fire will cycle and maintain operating pressure in the steam generator. For terminal stop, proceed as follows:



Coil Blowdown Valve 2
Fig. 6-8

1. Close the stop and check valve-15 and the remote control trainline shutoff valve-7 (if used).
2. Set the water by-pass regulator-111 to maximum output. When the generator steam pressure gauge-212 registers 200 pounds turn the control switch-102 to OFF.
3. Open the coil blowdown valve-2, Fig. 6-8. When

the generator pressure drops to 75 pounds, close the valve.

4. Open the separator blowdown valve-12 and blow down the steam separator-221 with the remaining pressure.
5. Fill the coils with water according to the procedure given on Page 604, with the exception that it will be found advantageous to fill a "hot" steam generator with the separator blowdown valve latched open, thereby purging the coils while also eliminating the discharge of steam at the fill test valve.
6. Close the atomizing air shutoff valve-1 and open the main switch.

LAYOVER OPERATION

1. Open steam admission valve to radiation-10.
2. Open layover connection shutoff valve-6.

NOTE: When starting, do not omit draining the steam separator, opening the fill-test valve, and again filling the steam generator with water. If the coils are already full, it will only take a moment for water to discharge from the fill-test valve.

FREEZING WEATHER PRECAUTIONS

The inlet valve-10 to the radiation-217 should be opened when operating during severe weather.

If a locomotive consist does not have all of its steam generators in operation, open the layover connection shutoff valve-6, the trainline pressure gauge steam admission valve-11, and the inlet valve-10 to the radiation on idle steam generators. Be sure coil blowdown valve-2 and stop and check valve-15 are closed.

If a locomotive is left standing out of service, operate one of the steam generators or make a connection to the yard steam line.

If no steam at all is available, thoroughly drain the steam generator. Open the drain valves-20 and 22, the water pump test valve-18, the coil blowdown valve-2, the separator blowdown valve-12 and the coil shutoff valve-3. Break the pipe connections where necessary to completely drain the piping. Turn the water pump by hand to clear it of water, or blow it out with compressed air. Remove the cover of the water treatment or water strainer tank-234 and make sure it is drained.

TROUBLE SHOOTING

If one of the protective switches (magnetic overload relay, coil blowdown switch or stack switch) operates to shut down the steam generator, the alarm will ring and the GREEN "boiler off" signal will light.

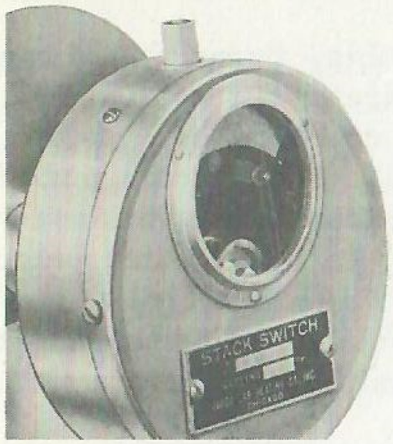
Turn the control switch-102 to OFF and use the following instructions as a guide in locating the trouble.

Motor And Burner Shut Down During Operation

1. Blown fuses: The alarm will not ring and the instrument lights will go out. The main fuse (or circuit breaker) is generally located in the electrical cabinet of the locomotive. Check this fuse, and check the control fuses in the steam generator control cabinet. A test lamp and fuse clips wired inside the electrical cabinet may be used to check the fuses.

2. Overload reset button-106 "out:" The alarm will ring; the instrument lights will remain on. Turn the control switch-102 OFF; check for hot blower-202

or water pump-230 bearings and for poorly adjusted pulley belts. Check the setting of the belt tension adjuster. Push the overload reset button "IN."



Stack Switch
Fig. 6-9

3. Stack switch-109, Fig. 6-9, reset button "OUT." Stack switch high temperature contacts are open. The alarm rings, instrument lights remain on. Turn control switch-102 to "OFF"; open the separator blowdown valve-12 and drain steam separator. Push in stack switch reset button. Open Fill-Test valve-4 and turn control switch to "FILL." When water discharges from Fill-Test valve, turn control switch to "OFF," close Fill-Test valve and start steam generator as usual.

4. Coil blowdown valve-2 partially open: The alarm rings, instrument lights remain on. Turn the control switch to OFF. Be sure that the coil blowdown valve handles is properly seated in the closed position, then start as usual.

5. Air switch-101 contacts open: The alarm sounds, instrument lights remain on. Turn control switch off. Be sure that the air admission valve-1 is fully open. Clean the strainer screen in the air line, and drain the air pressure regulator-100. If the low atomizing air pressure persists, increase the pressure by turning the regulator adjusting screw clockwise. When air pressure is restored, start as usual.

Motor Starts But Burner Does Not

If the fire fails to light the low temperature contacts on the stack switch-109 will not close and after a 45 second time delay the outfire relay will open the

circuit to shut down the steam generator. The alarm will ring and the instrument lights will remain on. Turn the control switch-102 OFF and check the following instructions for possible causes for the burner failure.

1. Ignition failure: Turn control switch to FILL -- no spark visible through the peep hole glass, or spark is of low intensity. If an ignition fuse is blown or if the current flow is broken for any other reason, the ignition circuit will be inoperative. If the spark plug electrodes are dirty or too far apart or if the electrodes are too close together, the ignition circuit will not operate properly.

   Check the ignition fuses -- use the test lamp and clips installed in the electrical cabinet for that purpose. Tighten loose cable connections and replace chafed or broken wire which may be breaking or grounding the circuit.

2. Low atomizing air pressure-201: The air switch-101 opens and breaks the circuit to the fuel solenoid valve-104, which then stops the flow of fuel to the sprayhead-105.

   Be sure the air admission valve is fully open. Clean the strainer screen in the atomizing air line and drain the atomizing air pressure regulator-100. If the low atomizing air pressure persists, tighten the adjusting screw at the top of the air pressure regulator to increase the atomizing pressure.

3. Low fuel manifold pressure-208: Turn the handle on the suction line fuel filter-206 several times. A slight suction leak may cause the manifold pressure to build up slowly; put the control switch-102 on FILL to bleed the fuel line and bring the manifold pressure up to normal.

4. Low fuel nozzle pressure-207: Lack of water causes the servo fuel control-108 to limit the supply of fuel entering the nozzle. (If the water supply is almost

completely stopped, the cam plate may come down far enough to actuate the cutout switch on the servo and close the fuel solenoid valve-104.)

Be sure that the pump belts have proper tension, the water pump test valve-18 is closed, the cover on the water treatment or strainer tank-234 is tight, the three-way washout valve-17 is fully open, and that the drain valves-20 and 22 are tightly closed.

Open and close the water by-pass regulator-111 adjusting handle several times to free the regulator from possible sediment. If the water pressure gauge-229 still registers low, close the water by-pass regulator shutoff valve-19. This closes the water by-pass line and permits all of the feed water to flow to the servo-fuel control-108; the steam generator will start at once if the by-pass regulator is causing the trouble. Set and manually regulate the trainline steam pressure by adjusting the manual water by-pass valve-8.

High feed water temperature or leaky water line connections may cause the water pump-230 to become air or vapor bound. Violent fluctuation of the water pressure gauge needle indicates this condition. Tighten leaky water line connections and bleed the line by opening the water pump test valve-18. Allow water to flow from this valve until no air or vapor bubbles are evident in the water.

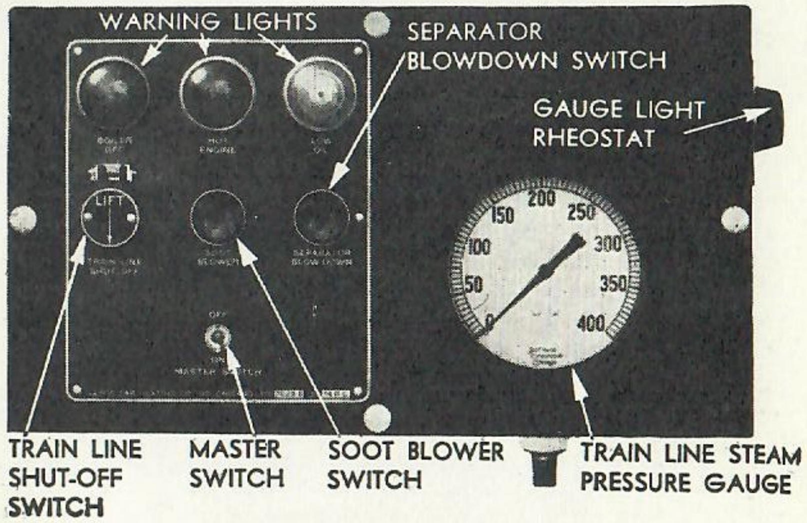
Irregular Trainline Pressure

1. Burner cycles off and on: Insufficient water delivery causes the steam generator to run in superheat; the steam temperature limit control-110 operates to protect the coils against overheating. Check the water pump output as instructed in the preceding paragraphs.

2. Safety valves blow: Shut down the steam generator. Lower the trainline pressure setting on the adjusting handle of the water by-pass regulator-111 and start the steam generator again. If the safety valves-107 continue to pop, close the water by-pass regulator shutoff valve-19 and manually regulate the trainline steam pressure by opening and adjusting the manual water by-pass valve-8.

REMOTE CONTROL EQUIPMENT

The remote control panel is located on the fireman's side of the locomotive cab. Mounted on it are a master switch to make the panel operative, and push-button switches to operate the separator blowdown valve-12 and the remote control trainline shutoff valve-7. A trainline steam pressure gauge is mounted on the panel.



Remote Control Panel
Fig. 6-10

The remote control trainline shutoff valve-7 can be closed from the cab; but must be opened manually. Depress the reset lever-7a on the trainline shutoff valve-7 to the position marked "open."

ITEMS TO REPORT

1. Water pressure greater than 100 pounds above normal.
2. Excessive stack temperature.
3. Fluctuation of the fuel manifold pressure.
4. Frequent cycling of the burner.
5. Water flow indicator not cycling.
6. Water by-pass regulator inoperative.
7. Any faulty operation of the steam generator.

VAPOR HEATING OK-SERIES STEAM GENERATOR TROUBLE SHOOTING CHART

Symptons	Cause of Trouble	Remedy
Panel lights do not light; bell does not ring (Control switch "OFF" main boiler switch "ON")	Main battery switch "OPEN"	Close
	Auxiliary generator switch "OPEN"	Close
	100-150 amp. boiler fuse (2) for each steam gen."Blown"	Test and replace
	15 amp. control fuse (2 on boiler panel) "Blown"	Test and replace
Motor does not run (control switch-102 on "FILL," bell rings)	Stack switch tripped	Reset
	Motor overload tripped	Reset
	Coil blowdown valve-2 "OPEN"	Close
Motor runs, no strong flow of water from water pump test valve	Water tank empty	Fill
	Valve-21 on suction line closed (on line to treatment tank)	Open
	Drain valve-20 on suction line or treatment tank open	Close
	Top of treatment tank not tight	Reset and tighten
	Treatment tank strainer clogged	Clean
	Water in storage tank too hot	Make sure steam heat valve to water tank is closed

VAPOR HEATING OK-SERIES STEAM GENERATOR TROUBLE SHOOTING CHART (CONT'D)

Symptoms	Cause of Trouble	Remedy
Motor runs, no spark at electrodes	Wires from electrodes to transformer broken or grounded	Repair
	Terminals loose on transformer	Tighten
	Gap between electrodes too wide	Reduce gap (should be 3/16")
	15 amp. ignition fuse (2 on boiler panel) "Blown."	Test and replace
Motor runs, fire does not light when switch is moved to "Run"	Atomizing air valve-1 closed	Open
	Motor not allowed to stop after filling, before turning boiler control switch-102 to "Run"	Turn to "Fill" briefly, then to "Off." After motor has stopped and servo control is all the way down, turn to "Run."
	Electrodes not properly adjusted	Adjust. Report to maintenance.
	Nozzle not properly adjusted	Adjust. Report to maintenance.
Generator shuts off, bell rings	Stack switch tripped	Reset stack switch, refill coils, start steam generator, and set water by-pass regulator at next lower pressure. Report to maintenance.

VAPOR HEATING OK-SERIES STEAM GENERATOR TROUBLE SHOOTING CHART (CONT'D)

Symptoms	Cause of Trouble	Remedy
Generator shuts off, bell rings	Motor overload relay trips, shutting down generator	Reset overload relay, refill coils and start steam generator. Report to maintenance.
Generator runs, dome gets hot	Lack of air, dirty coils	Set water by-pass regulator to next lower position. Report to maintenance.
Generator runs but no water returns through water flow indicator	Valve-9 in return line from separator closed	Open
	Return water strainer clogged	Clean
	Steam too dry	Report to maintenance.
Generator runs but generator and train-line pressure cannot be controlled by water by-pass regulator	Steam admission valve-13 closed	Open
	Water admission valve-3 closed	Open
	Defective water by-pass regulator	Close water shutoff valve-19 to water by-pass regulator, use manual by-pass valve-8 to control pressure. Report to maintenance.

STEAM GENERATOR OPERATION CHART

VALVES

Valves designated by odd numbers are fitted with cross type handles, and must be OPEN during normal operation of the steam generator; valves designated by even numbers are fitted with standard round handles, and must be CLOSED during normal operation of the steam generator. This applies only to the OK series steam generators.

The following valves must be CLOSED during normal operation of the steam generator:

2. Coil Blowdown Valve and Switch
4. Fill-Test Valve
6. Layover Connection Shutoff Valve
8. Manual Water By-Pass Valve
10. Steam Admission Valve to Radiation (Open in cold weather)
12. Steam Separator Blowdown Valve
14. Washout Inlet Valve
16. Washout Inlet Valve
18. Water Pump Test Valve
20. Water Suction Drain Valve
22. Water Treatment Tank Drain Valve
56. Return Line Valve (Standby)

The following valves must be OPEN during normal operation of the steam generator:

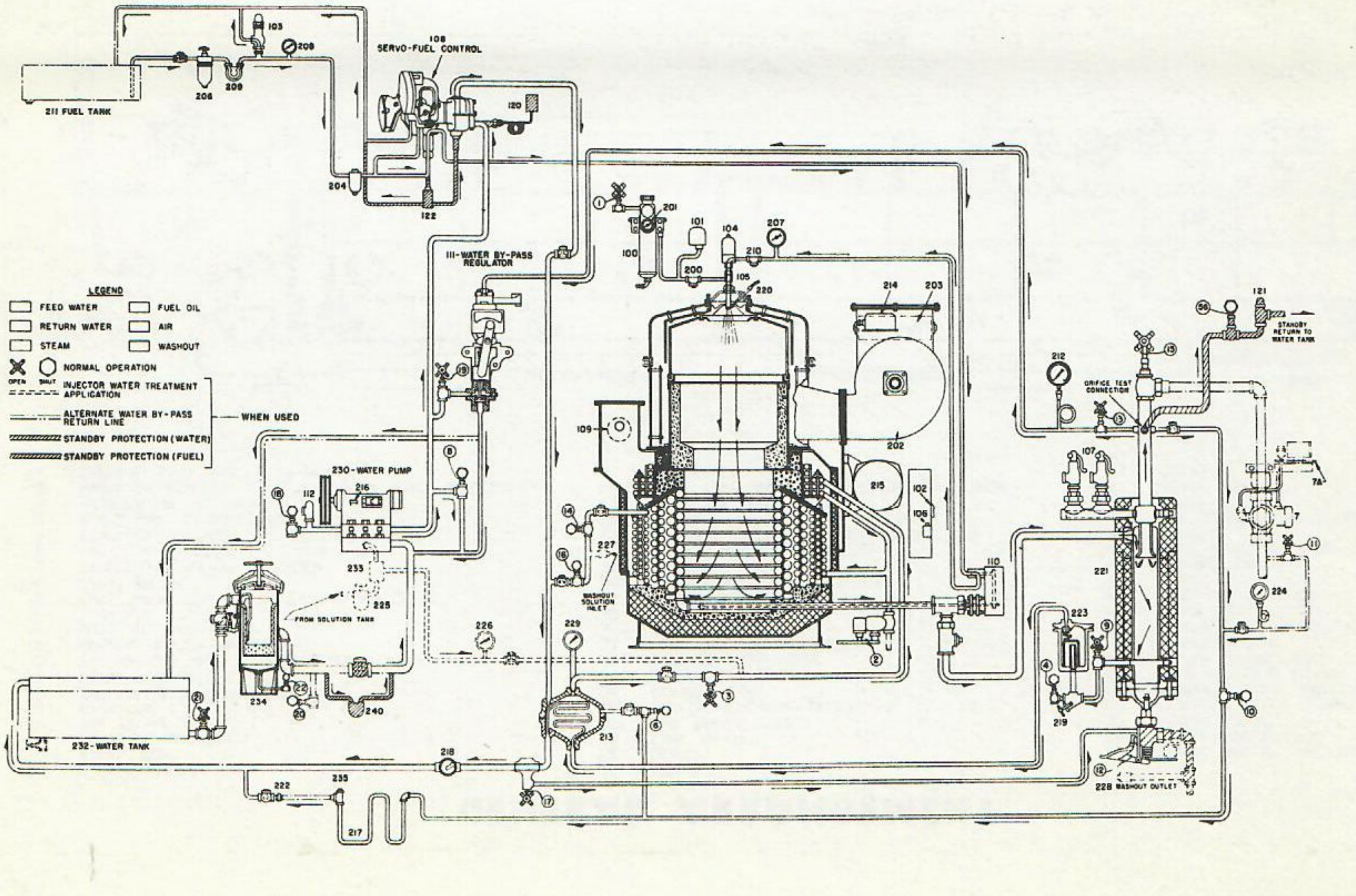
1. Atomizing Air Shutoff Valve
3. Coil Shutoff Valve
7. Remote Control Trainline Shutoff Valve
7a. Reset Lever
9. Return Water Outlet Valve
11. Steam Admission Valve to Trainline Pressure Gauge
13. Steam Admission Valve to Water By-Pass Regulator
15. Stop and Check Valve (Closed during start or shut down procedure)
17. Three-Way Washout Valve
19. Water By-Pass Regulator Shutoff Valve
21. Water Supply Stop Valve

CONTROLS

100. Atomizing Air Pressure Regulator
101. Atomizing Air Switch
102. Control Switch
103. Fuel Pressure Regulator
104. Fuel Solenoid Valve
105. Fuel Spray Head
106. Overload Reset Button, Motor
107. Safety Valves
108. Servo-Fuel Control and Switch
109. Stack Switch
110. Steam Temperature Limit Control
111. Water By-Pass Regulator and Switch
112. Water Pressure Relief Valve
120. Aquastat (Standby)
121. Relief Valve (Standby)
122. Fuel By-Pass Solenoid Valve (Standby)

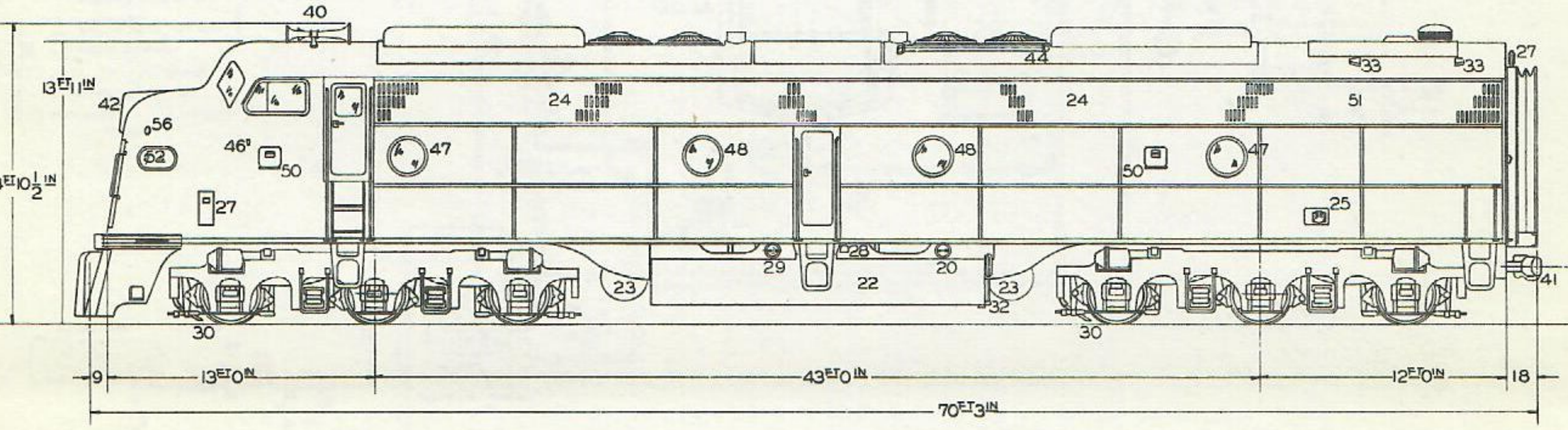
APPURTENANCES

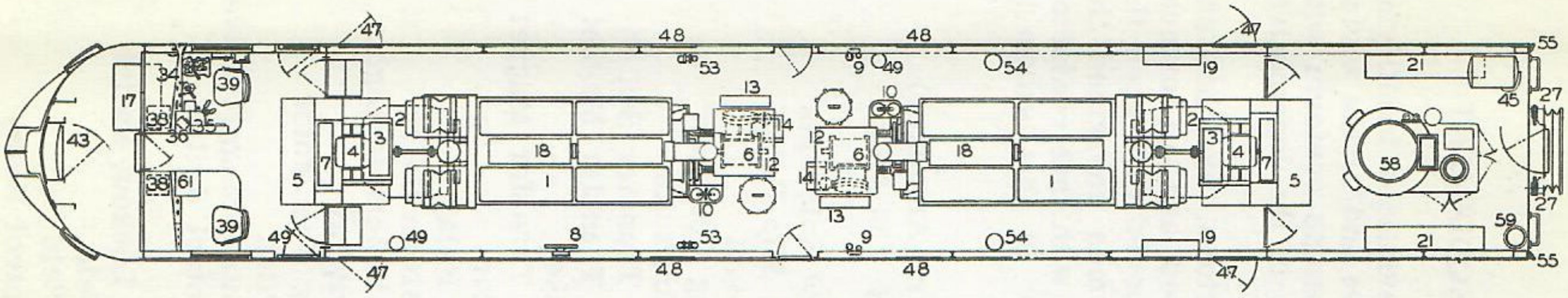
200. Atomizing Air Strainer
201. Atomizing Air Pressure Gauge
202. Blower
203. Damper
204. Fuel Filter (Pressure line)
206. Fuel Filter (Suction line)
207. Fuel Nozzle Pressure Gauge
208. Fuel Pressure Gauge (At fuel pressure regulator)
209. Fuel Pump
210. Fuel Strainer
211. Fuel Tank
212. Generator Steam Pressure Gauge
213. Heat Exchanger
214. Ignition Transformer
215. Motor Converter
216. Oil Filter Cap
217. Radiation
218. Return Water Flow Indicator
219. Return Water Strainer
220. Spark Plugs
221. Steam Separator
222. Orifice Nipple (Radiation)
223. Steam Trap (Return water line)
224. Trainline Steam Pressure Gauge
225. Treatment Injector Filter
226. Treatment Injector Gauge
227. Washout Solution Inlet
228. Washout Solution Outlet
229. Water Pressure Gauge
230. Water Pump
232. Water Tank
233. Water Treatment Injector Pump
234. Water Treatment Tank (Strainer tank only if injector system is used)
235. Strainer Tee
240. Circulating Pump (Standby)

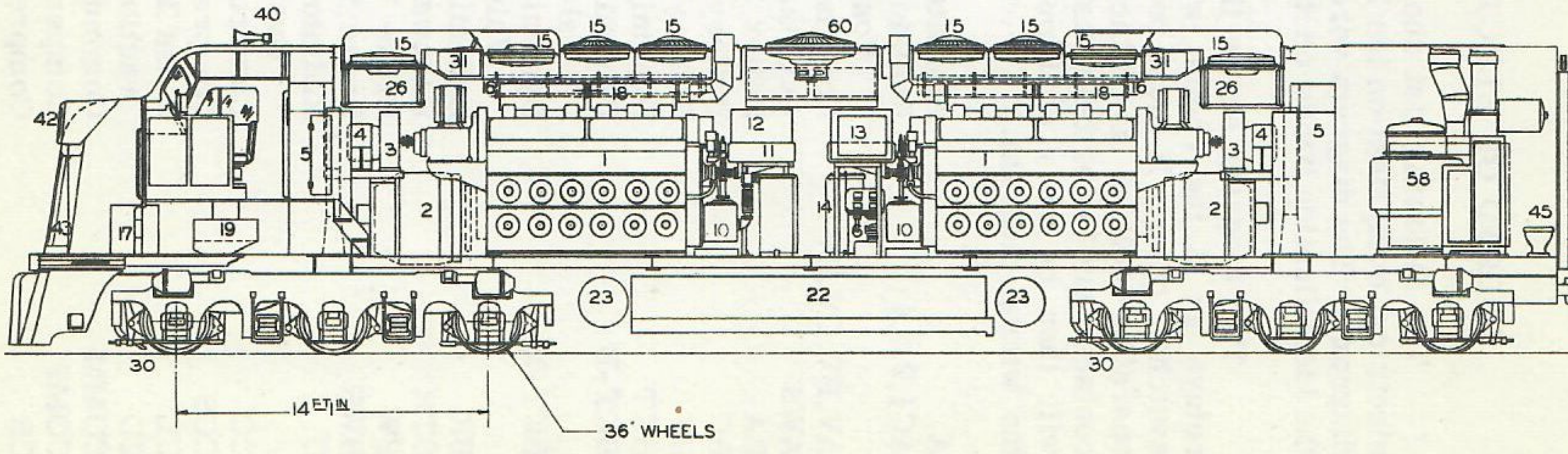

211 FUEL TANK
103
208
206
209
108 SERVO-FUEL CONTROL
120
204
122
111-WATER BY-PASS REGULATOR
201
101
100
104
207
210
200
105
220
214
203
109
202
215
102
106
110
227
WASHOUT SOLUTION INLET
226
229
213
218
235
222
217
230-WATER PUMP
216
112
233
225
FROM SOLUTION TANK
234
240
232-WATER TANK
212
ORIFICE TEST CONNECTION
107
121
STANDBY RETURN TO WATER TANK
7A
221
223
224
219
228 WASHOUT OUTLET
LEGEND
FEED WATER
FUEL OIL
RETURN WATER
AIR
STEAM
WASHOUT
OPEN SHUT NORMAL OPERATION
INJECTOR WATER TREATMENT APPLICATION
ALTERNATE WATER BY-PASS RETURN LINE
WHEN USED
STANDBY PROTECTION (WATER)
STANDBY PROTECTION (FUEL)

GENERAL ARRANGEMENT

No.	Item
20	FUEL FILLER
19	SAND BOX
18	EXHAUST MANIFOLD
17	AIR BRAKE RACK
16	RADIATOR
15	36" FAN & MOTOR
14	LOAD REGULATOR
13	ENGINE CONTROL & INSTRUMENT PANEL
12	ENGINE WATER TANK
11	LUBE OIL COOLER
10	LUBE OIL FILLER
9	FUEL TANK VENT WITH FLAME ARRESTOR
8	HAND BRAKE
7	TRACTION MOTOR BLOWER
6	AIR COMPRESSOR
5	CONTROL CABINET
4	AUXILIARY GENERATOR
3	GENERATOR BLOWER
2	MAIN GENERATOR & ALTERNATOR EMD MODEL
1	ENGINE EMD MODEL 12-567 C
40	HORN
39	SEAT
38	CAB HEATER
37	AIR BRAKE STAND
36	SPEEDOMETER RECORDER
35	CONTROLLER
34	INSTRUMENT PANEL
33	BATTERY BOX VENT
32	FUEL TANK SIGHT GLASS
31	A.C. CABINET
30	SANDING NOZZLES
29	WATER FILLER
28	EMERGENCY FUEL CUT-OFF
27	LIFTING LUGS
26	ENGINE ROOM VENTILATOR
25	BATTERY CHARGING RECEPTACLE
24	AIR INTAKE-SHUTTERS & GRILLE
23	MAIN AIR RESERVOIR
22	FUEL 1200 GAL & WATER 1350 GAL TANK
21	BATTERIES
59	LIQUID WATER TREATMENT
58	STEAM GENERATOR
57	SIGNAL LIGHT
56	CLASSIFICATION LIGHT
55	MARKER LIGHT BRACKETS
54	M. R. PIPELINE FILTER
53	WATER TANK VENT
52	NUMBER BOX
51	VENTILATING SHUTTERS
50	SAND BOX FILLER
49	FIRE EXTINGUISHER
48	FIXED SASH
47	HINGED SASH
46	BLUE FLAG BRACKET
45	TOILET
44	AIR COMPRESSOR AFTERCOOLER
43	DOOR-PLAIN
42	HEAD LIGHT
41	COUPLER







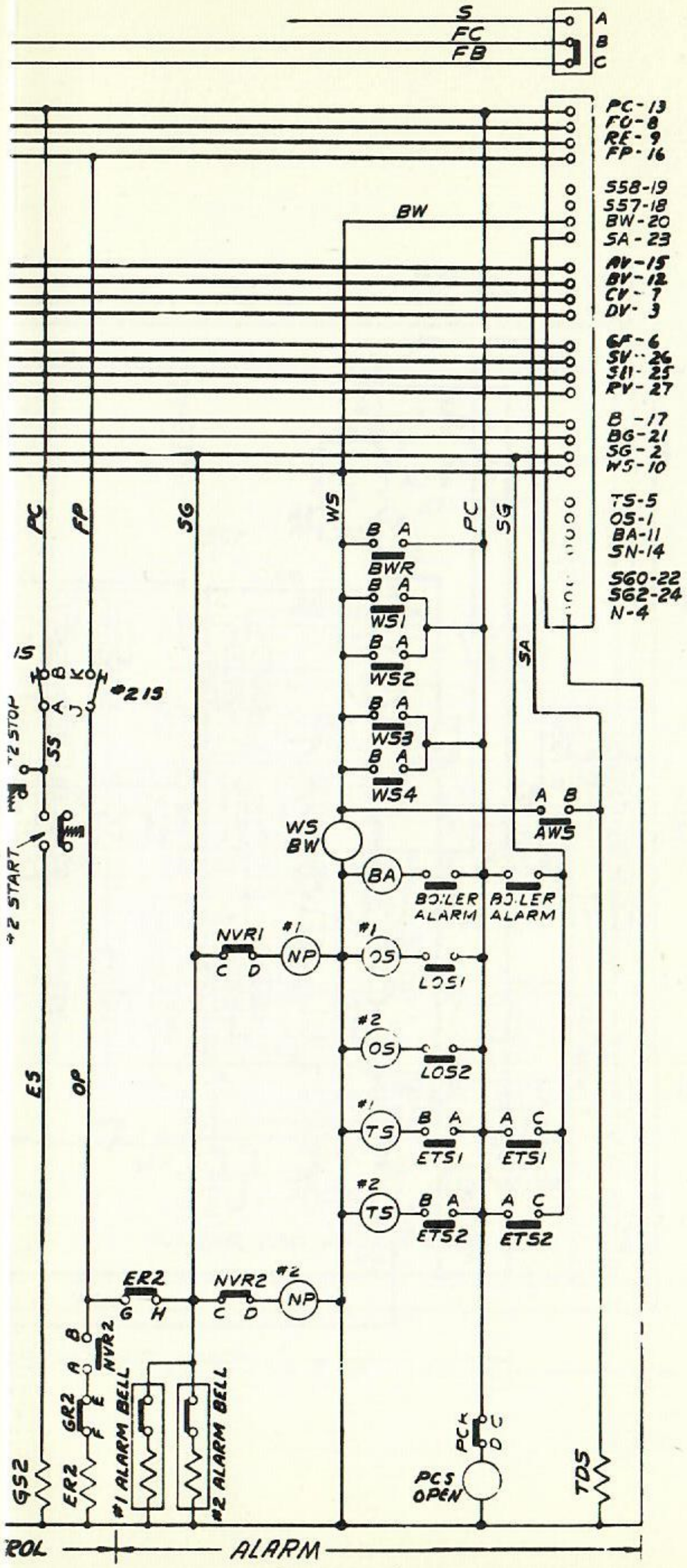
LEGEND OF ELECTRICAL EQUIPMENT

The following list shows abbreviations identifying electrical equipment on the locomotive and/or the wiring diagrams. The diagram wire designations conform with the identification bands on the wires in the locomotive.

The diagram shows the contactors, switches and relays as if the engine was stopped and all manual switches open. It must be remembered that when the operating coil of a contactor becomes energized the contacts and interlocks associated with that contactor will then be in a position opposite to that shown in the wiring diagram.

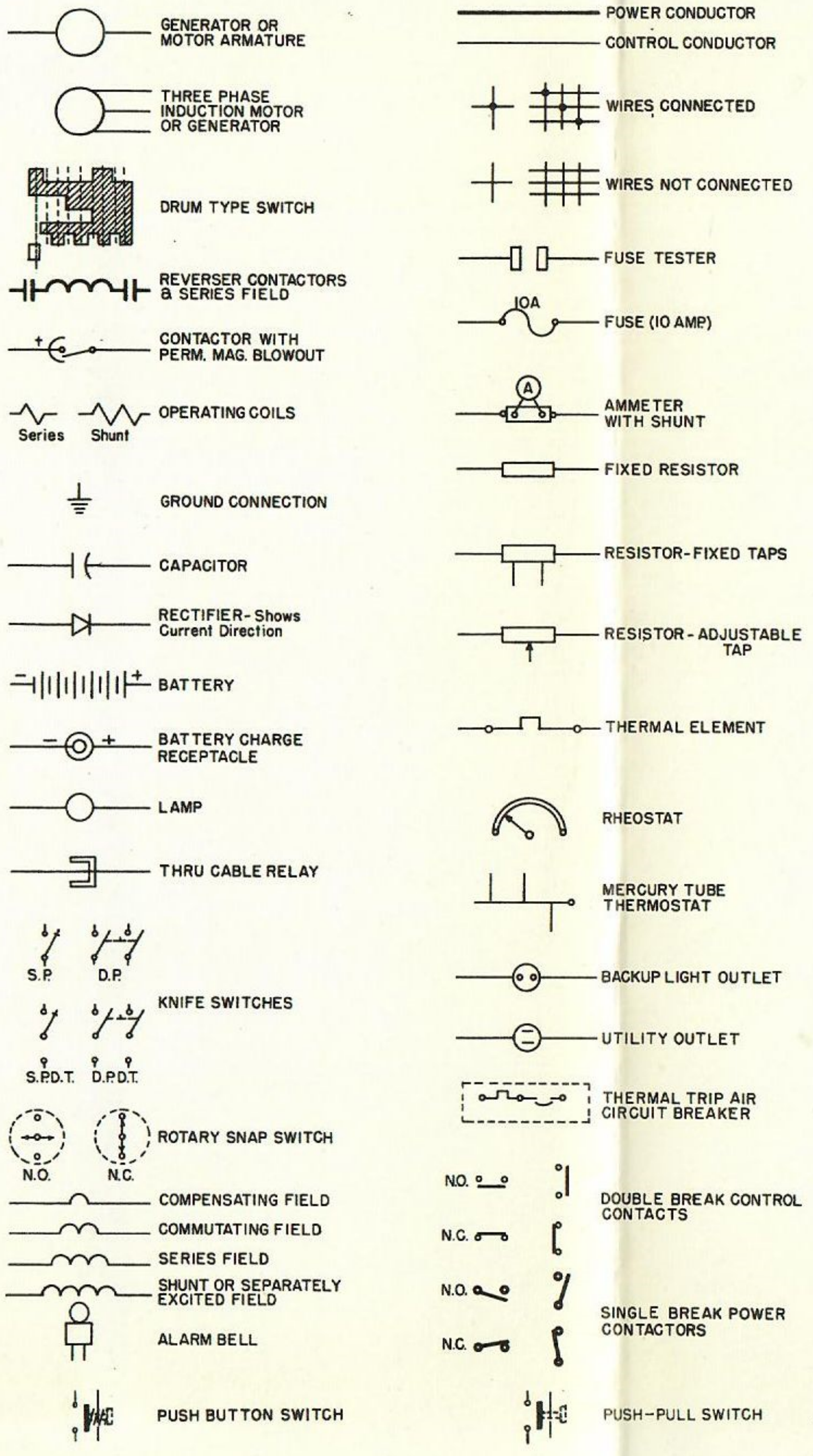
A	Ammeter (Battery Ammeter)
AC1,2,3,4	Radiator Cooling Fan Motor Contactors
AV,BV,CV,DV	Governor Control Solenoids
AWS	Auxiliary Wheel Slip Relay
BA	Boiler Alarm Light
BC	Battery Charging Contactor
BF	Battery Field Contactor
BKT	Dynamic Brake Transfer Switch
BKT-B	Dynamic Brake Transfer Magnet Valve - Brake
BKT-M	Dynamic Brake Transfer Magnet Valve - Motor
BR	Dynamic Brake Relay
BTR	Backward Transition Relay
BW	Brake Warning Indicating Light
BWR	Brake Warning Relay
C	Radiator Cooling Fan Motor Overload Switch
CC	Compressor Control Magnet Valve
CCS	Compressor Control Switch
CL	Class Light
CD	Traction Motor Lockout Switch
COMM	Commutating Field
COMP	Compensating Field
CR	Compressor Control Relay
DIFF	Differential Field
ER	Engine Relay (ER Relay)
ETS	Engine High Temperature Switch
FL	Field Loop Contactor
FMV or FSV	Forward Sanding Magnet Valve
FPC	Fuel Pump Contactor
FS	Traction Motor Field Shunting Contactor
FSD	Field Shunting Delay Relay
FSR	Field Shunting Relay
FTR	Forward Transition Relay
GA	Gauge Light or Switch
GF	Generator Field Contactor
GR	Ground Relay
GS$^{\pm}$ or ST$^{\pm}$	Generator Starting Contactors
I	Dynamic Brake and Load Indicating Meter
IS	Isolation Switch
LOS	Low Oil Pressure Switch
LRC	Load Regulator Contactor
LRS	Load Regulator Contactor Switch (In Governor)
MBL	Traction Motor Blower Motor
NV	"Alternator Failure" or "No Power" Signal Light
NVR	"No AC Voltage" Relay
OLS	Governor Overload Switch
ORS	Governor Over-Riding Solenoid
OS	Low Oil Signal Light
P	Parallel Power Contactor
PCR	Pneumatic Control Relay
PCS	Pneumatic Control Switch
RBL	Radiator Cooling Fan Blower Motor
RCR	Reverse Current Relay
RMV or RSV	Reverse Sanding Magnet Valve
RVR	Reverser Switch
RVR-F or FOR	Forward Magnet Valve or Reverser Switch
RVR-R or REV	Reverse Magnet Valve or Reverser Switch
S	Series Power Contactor
SF or SH	Shunt Field Contactor
SFT	Shunt Field Transfer Relay

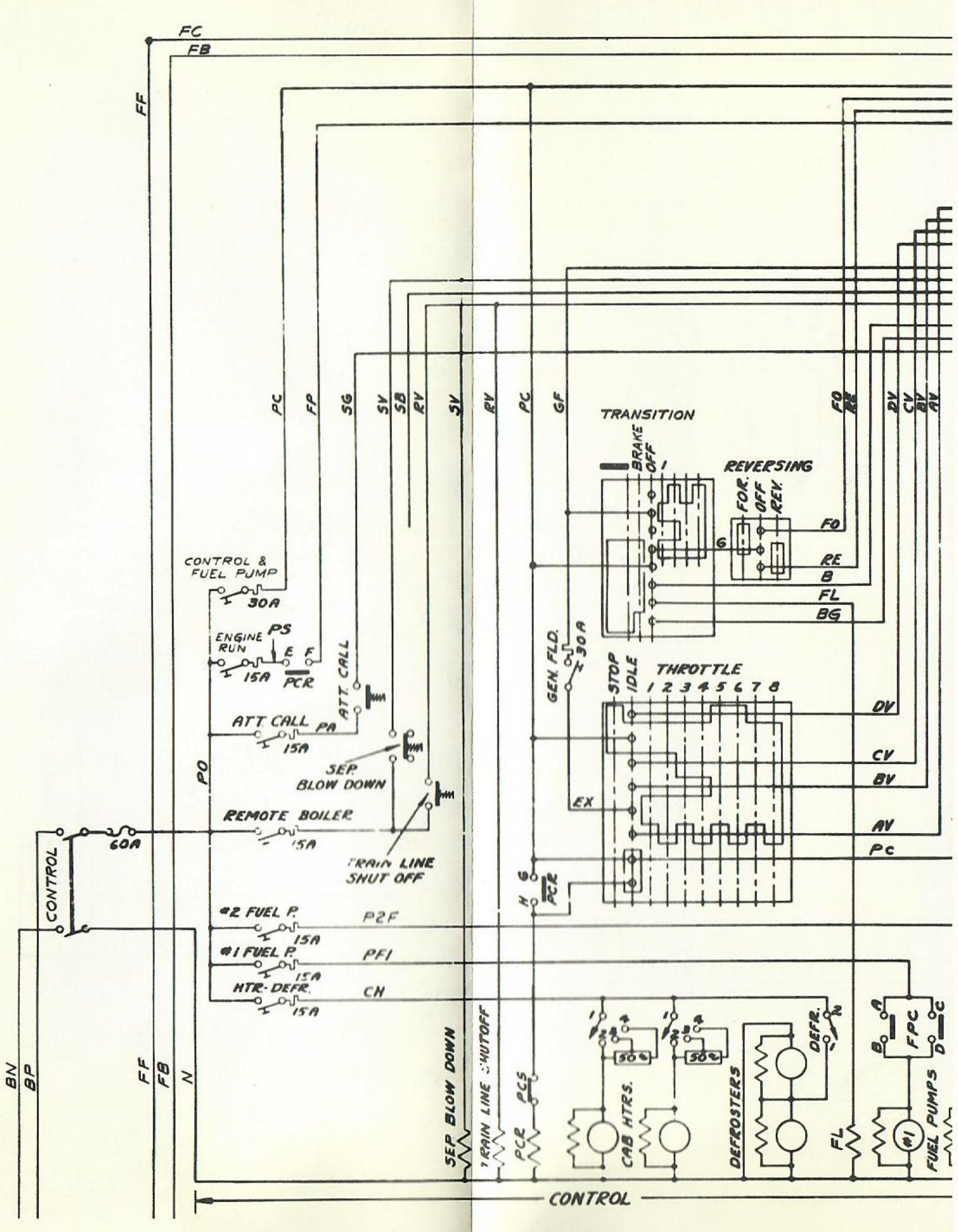
SMV	Shutter Magnet Valve
SR	Signal Relay
START	Starting Field
SWS	Summer-Winter Switch
TA-B-C-D	A-B-C and D Temperature Control Switches
TCR	Temperature Control Relay
TDB	Time Delay Backward
TDO	Time Delay Overload
TDR	Time Delay Relay
TDS	Time Delay Sanding Relay
TR	Transition Relay
TS	High Temperature (Hot engine) Signal Light
WCR	Wheel Creep Relay
WS	Wheel Slip Relay
WSA	Wheel Slip Auxiliary Relay
WSS	Wheel Slip Series Relay

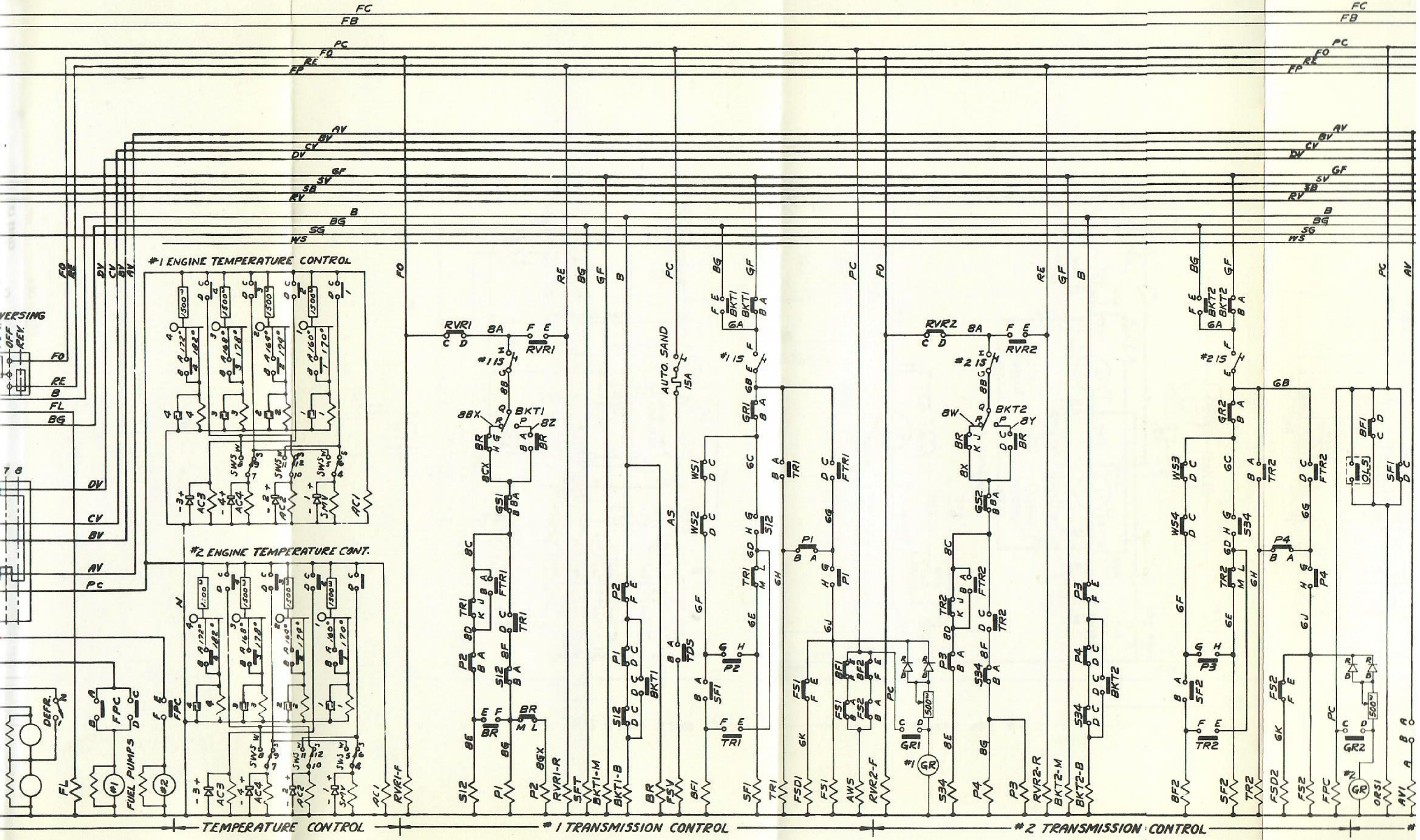

S
FC
FB
A
B
C
PC-13
FO-8
RE-9
FP-16
S58-19
S57-18
BW-20
SA-23
AV-15
BV-12
CV-7
DV-3
GF-6
SV-26
S11-25
RV-27
B-17
BG-21
SG-2
WS-10
TS-5
OS-1
BA-11
SN-14
S60-22
S62-24
N-4
BW
PC
FP
SG
WS
PC
SG
SA
B A
BWR
B A
WS1
B A
WS2
B A
WS3
B A
WS4
A B
AWS
IS
B K
A J
#215
#2 STOP
SS
#2 START
WS
BW
BA
BOILER ALARM
BOILER ALARM
NVR1
C D
#1
NP
#1
OS
LOS1
#2
OS
LOS2
#1
TS
B A
ETS1
A C
ETS1
#2
TS
B A
ETS2
A C
ETS2
ES
OP
ER2
G H
NVR2
C D
#2
NP
A B
NVR2
GR2
E F
#1 ALARM BELL
#2 ALARM BELL
GS2
ER2
PCK
D C
PCS OPEN
TDS
ROL
ALARM

SCHEMATIC BASIC WIRING DIAGRAM
E9 LOCOMOTIVE — DYNAMIC BRAKE

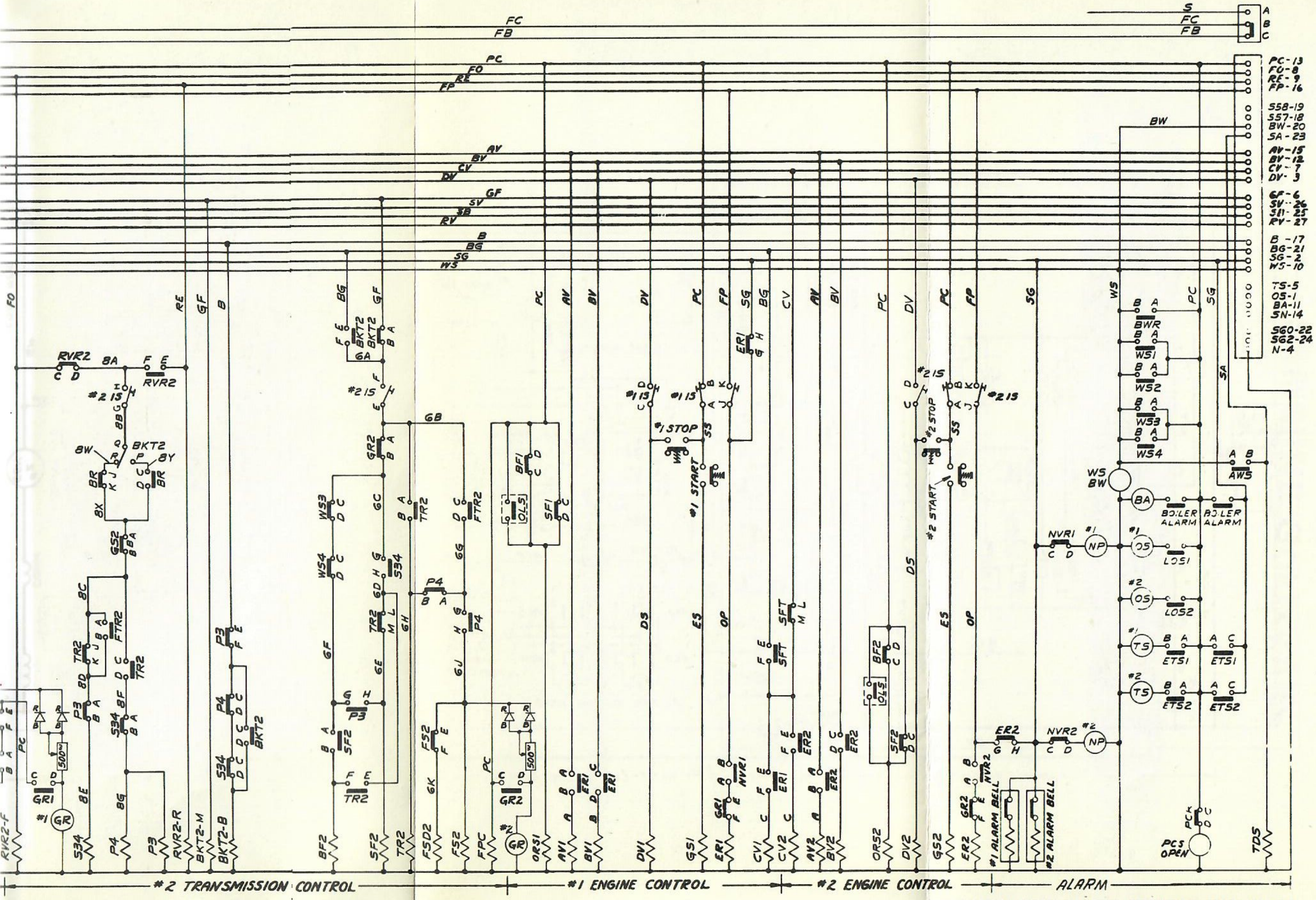
Electrical Symbols


GENERATOR OR MOTOR ARMATURE
THREE PHASE INDUCTION MOTOR OR GENERATOR
DRUM TYPE SWITCH
REVERSER CONTACTORS & SERIES FIELD
CONTACTOR WITH PERM. MAG. BLOWOUT
Series
Shunt
OPERATING COILS
GROUND CONNECTION
CAPACITOR
RECTIFIER- Shows Current Direction
BATTERY
BATTERY CHARGE RECEPTACLE
LAMP
THRU CABLE RELAY
S.P.
D.P.
KNIFE SWITCHES
S.P.D.T.
D.P.D.T.
N.O.
N.C.
ROTARY SNAP SWITCH
COMPENSATING FIELD
COMMUTATING FIELD
SERIES FIELD
SHUNT OR SEPARATELY EXCITED FIELD
ALARM BELL
PUSH BUTTON SWITCH
POWER CONDUCTOR
CONTROL CONDUCTOR
WIRES CONNECTED
WIRES NOT CONNECTED
FUSE TESTER
10A
FUSE (10 AMP)
A
AMMETER WITH SHUNT
FIXED RESISTOR
RESISTOR-FIXED TAPS
RESISTOR - ADJUSTABLE TAP
THERMAL ELEMENT
RHEOSTAT
MERCURY TUBE THERMOSTAT
BACKUP LIGHT OUTLET
UTILITY OUTLET
THERMAL TRIP AIR CIRCUIT BREAKER
N.O.
N.C.
DOUBLE BREAK CONTROL CONTACTS
N.O.
N.C.
SINGLE BREAK POWER CONTACTORS
PUSH-PULL SWITCH

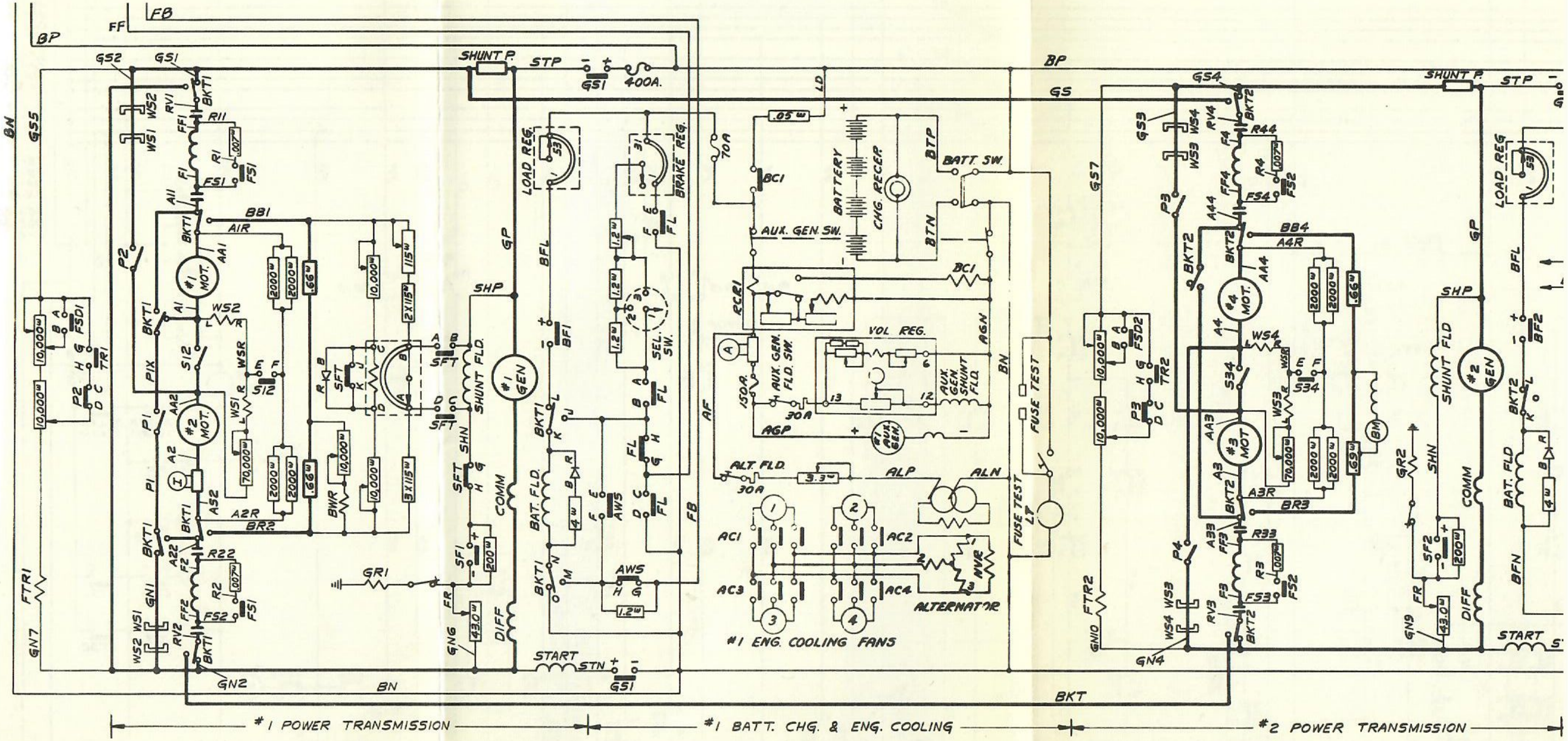

FC
FB
FF
PC
FP
SG
SV
SB
RV
SV
RV
PC
GF
TRANSITION
BRAKE OFF
1
REVERSING
FOR.
OFF
REV.
FO
RE
B
FL
BG
DV
CV
BV
AV
Pc
CONTROL & FUEL PUMP
30A
ENGINE RUN
PS
E
F
15A
PCR
ATT. CALL
ATT. CALL
PA
15A
SEP. BLOW DOWN
PO
REMOTE BOILER
15A
TRAIN LINE SHUT OFF
60A
CONTROL
GEN. FLD.
30A
STOP
IDLE
THROTTLE
1 2 3 4 5 6 7 8
EX
G
H
PCR
#2 FUEL P.
15A
P2F
#1 FUEL P.
15A
PF1
HTR.-DEFR.
15A
CH
BN
BP
FF
FB
N
SEP. BLOW DOWN
TRAIN LINE SHUTOFF
PCS
PCR
CAB HTRS.
50Ω
50Ω
DEFROSTERS
DEFR.
FL
A
B
FPC
C
D
#1
FUEL PUMPS
CONTROL



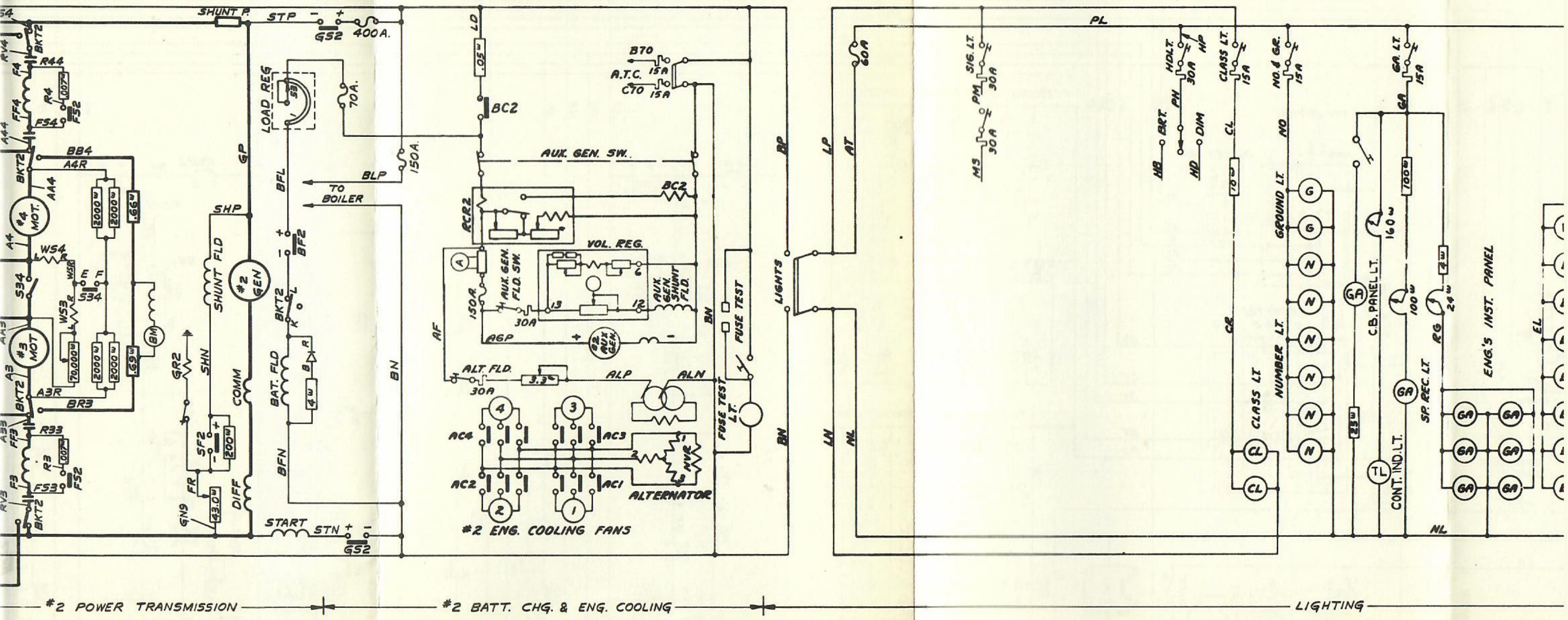
FC
FB
PC
FO
RE
FP
AV
BV
CV
DV
GF
SV
SB
RV
B
BG
SG
WS
#1 ENGINE TEMPERATURE CONTROL
#2 ENGINE TEMPERATURE CONT.
VERSING
OFF
REV.
FL
DEFR.
FPC
FUEL PUMPS
#1
#2
AC1
AC2
AC3
AC4
SMV
SWS
RVR1
RVR2
#1 IS
#2 IS
BKT1
BKT2
8BX
8BZ
8W
8Y
BR
GS1
GS2
FTR1
FTR2
TR1
TR2
P1
P2
P3
P4
S12
S34
AUTO. SAND
15A
AS
TDS
WS1
WS2
WS3
WS4
SF1
SF2
GR1
GR2
FS1
FS2
BF1
BF2
OLS
500W
#1 GR
#2 GR
RVR1-F
RVR1-R
SFT
BKT1-M
BKT1-B
FSV
FSD1
AWS
RVR2-F
RVR2-R
BKT2-M
BKT2-B
FSD2
ORS1
AV1
TEMPERATURE CONTROL
#1 TRANSMISSION CONTROL
#2 TRANSMISSION CONTROL

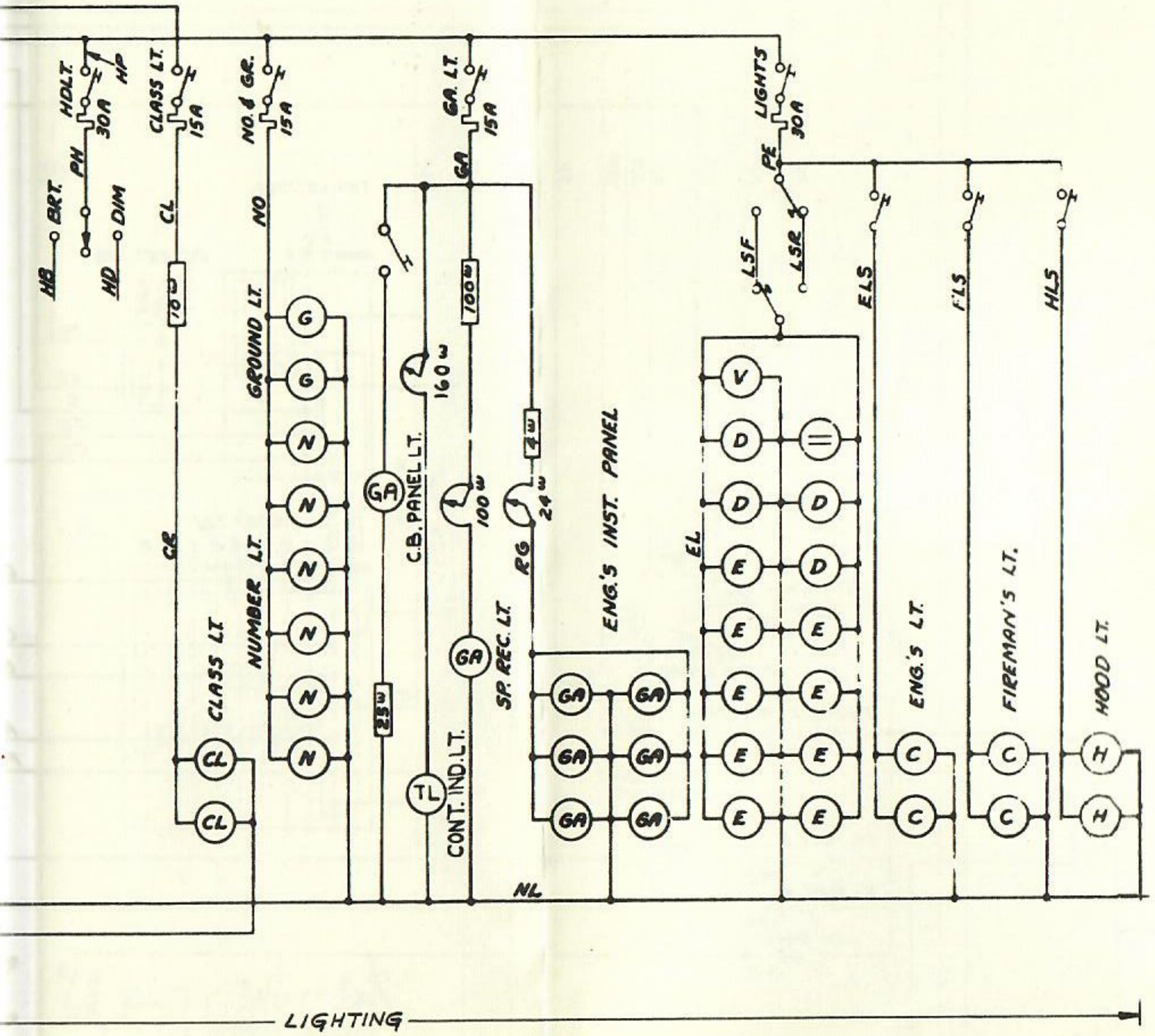

S
FC
FB
A
B
C
PC-13
FO-8
RE-9
FP-16
S58-19
S57-18
BW-20
SA-23
AV-15
BV-12
CV-7
DV-3
GF-6
SV-26
S11-25
RV-27
B-17
BG-21
SG-2
WS-10
TS-5
OS-1
BA-11
SN-14
S60-22
S62-24
N-4
PC
FO
RE
FP
AV
BV
CV
DV
GF
SV
SB
RV
B
BG
SG
WS
BW
SA
RVR2
BKT2
BR
GS2
TR2
FTR2
P3
S34
GR1
#1 GR
500Ω
#2 15
WS3
WS4
GR2
P4
SF2
FS2
BF1
OLS
SF1
#2 GR
#1 15
#1 STOP
#1 START
ER1
NVR1
SFT
ER2
BF2
#2 STOP
#2 START
#2 15
NVR2
BWR
WS1
WS2
WS3
WS4
AWS
WS BW
BA
BOILER ALARM
BOILER ALARM
NP
#1 OS
LOS1
#2 OS
LOS2
#1 TS
ETS1
#2 TS
ETS2
PCS OPEN
RVR2-F
S34
P4
P3
RVR2-R
BKT2-M
BKT2-B
BF2
SF2
TR2
FSD2
FS2
FPC
ORS1
AV1
BV1
DV1
GS1
ER1
CV1
CV2
AV2
BV2
ORS2
DV2
GS2
ER2
#1 ALARM BELL
#2 ALARM BELL
TDS
#2 TRANSMISSION CONTROL
#1 ENGINE CONTROL
#2 ENGINE CONTROL
ALARM

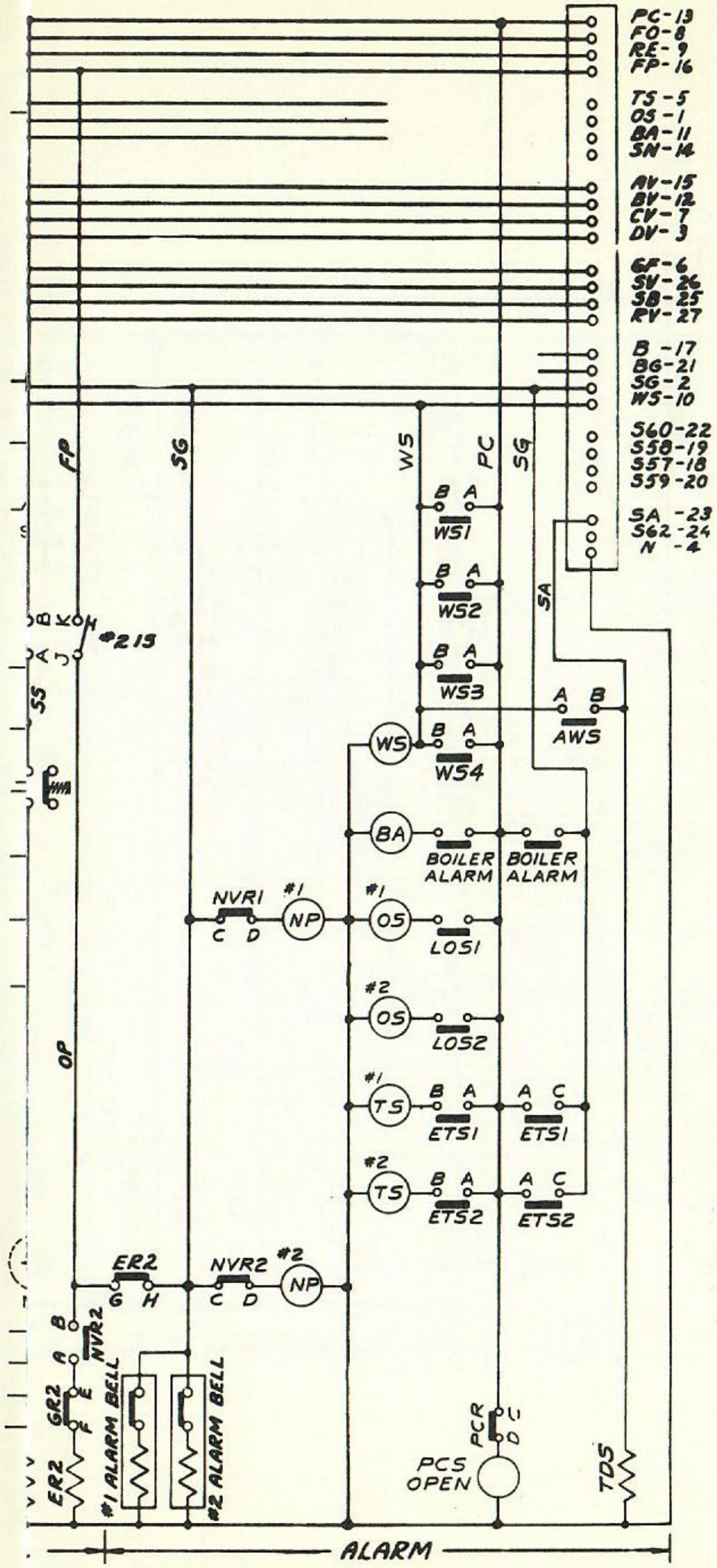
SCHEMATIC BASIC WIRING DIAGRAM
E9 LOCOMOTIVE — DYNAMIC BRAKE



BP
FF
FB
BN
GS5
GS2
GS1
BKT1
SHUNT P.
STP
400A.
WS1
WS2
RV1
FF1
R11
R1
.007w
FS1
F1
A11
#1 MOT.
AA1
BB1
A1R
P2
A1
WS2
S12
P1X
WSR
E F
#2 MOT.
AA2
P1
A2
A2R
BR2
A22
R22
F2
FF2
R2
FS2
GN1
RV2
GN2
2000w
.66w
10,000w
115w
2X115w
3X115w
70,000w
BWR
SFT
SHP
GP
SHUNT FLD.
#1 GEN.
SHN
SF1
200w
COMM
GR1
FR
43.0w
GN6
DIFF
START
STN
FSD1
TR1
10,000w
FTR1
GN7
LOAD REG.
53
BRAKE REG.
31
BFL
BF1
1.2w
SEL. SW.
FL
BAT. FLD.
4w
AWS
70A
LD
.05w
BC1
BATTERY
CHG. RECEP.
BTP
BTN
BATT. SW.
AUX. GEN. SW.
RCR1
AGN
VOL REG.
A
150A.
AUX. GEN. FLD. SW.
30A
AUX. GEN. SHUNT FLD.
#1 AUX. GEN.
AGP
AF
ALT. FLD.
3.3w
ALP
ALN
AC1
AC2
AC3
AC4
NVR
ALTERNATOR
#1 ENG. COOLING FANS
FUSE TEST
FUSE TEST LT.
GS
GS4
GS7
GS3
WS3
WS4
RV4
BKT2
R44
F4
R4
FS2
FF4
FS4
AA4
BB4
A4R
#4 MOT.
A4
WS4
S34
#3 MOT.
AA3
A3
A3R
BR3
69w
BM
P3
P4
FSD2
TR2
FTR2
GN10
GN4
A33
R33
FF3
F3
FS3
R3
RV3
GR2
SF2
#2 GEN.
SHUNT FLD
GN9
BF2
BFN
BKT
#1 POWER TRANSMISSION
#1 BATT. CHG. & ENG. COOLING
#2 POWER TRANSMISSION

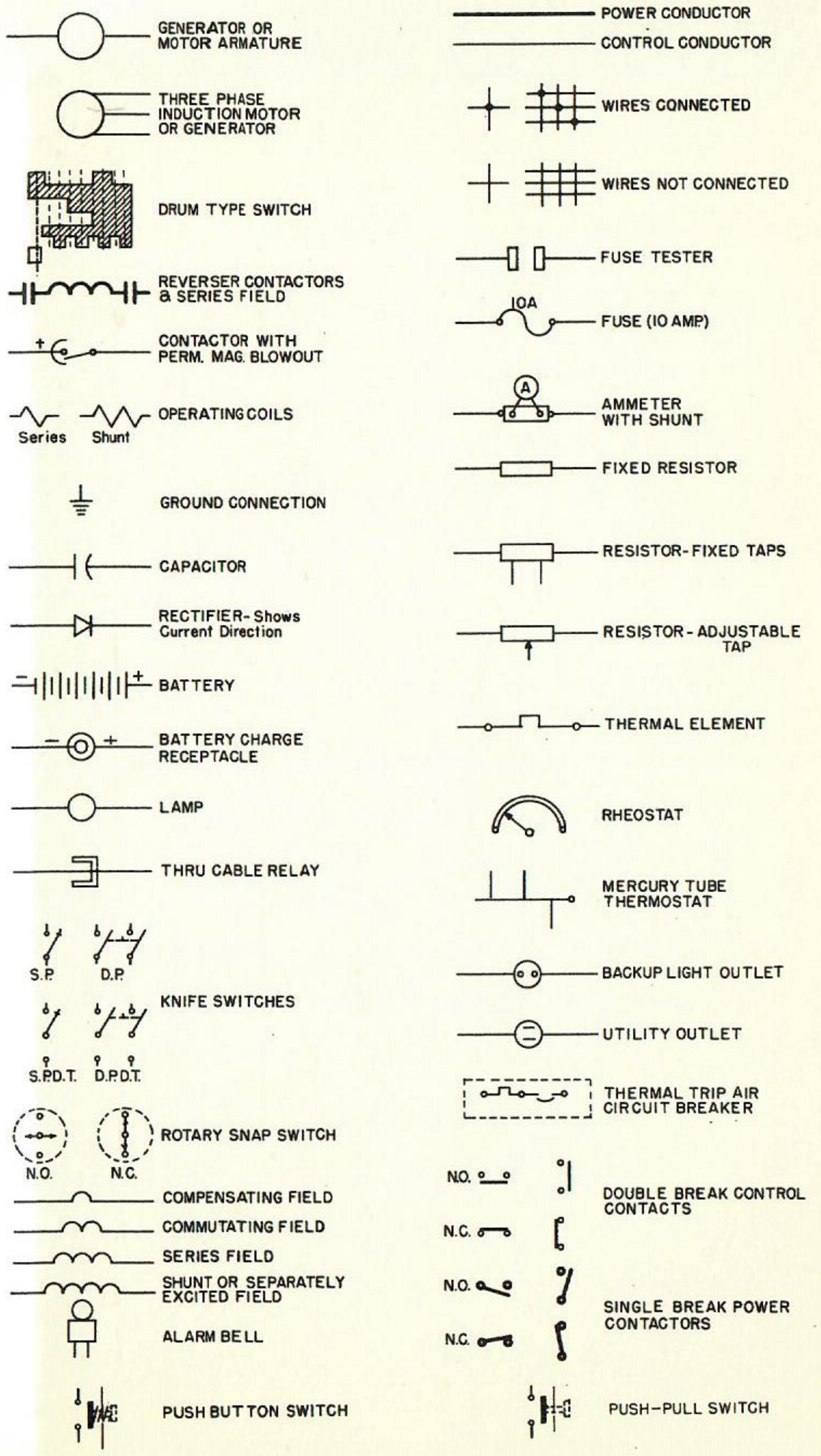

SHUNT P.
STP
GS2
400A.
LOAD REG
70A.
GP
BFL
BLP
150A
TO
BOILER
SHP
SHUNT FLD
#2
GEN
BF2
BKT2
BAT. FLD
4w
SHN
GR2
COMM
SF2
200w
FR
43.0w
GN9
DIFF
BFN
BN
START
STN
GS2
BKT2
R44
F4
R4
.007w
FS2
FF4
FS54
AA4
BB4
A4R
2000w
.66w
#4
MOT.
A4
WS4
S34
WS3
70,000w
.69w
#3
MOT
A3
A3R
BR3
R33
R3
FS3
FS53
RV3
RV4
LD
.05w
B70
A.T.C.
C70
15A
BC2
AUX. GEN. SW.
BC2
RCR2
VOL. REG.
AUX. GEN. FLD. SW.
150A
30A
13
12
6
AUX. GEN. SHUNT FLD.
A6P
#2 AUX GEN.
AF
ALT. FLD.
30A
3.3w
ALP
ALN
AC4
AC3
AC2
AC1
NVR
ALTERNATOR
#2 ENG. COOLING FANS
BP
BN
FUSE TEST
FUSE TEST LT.
LIGHTS
BN
LP
AT
LN
NL
60A
SIG. LT.
PM
30A
MS
PL
HDLT.
HP
PH
30A
BRT.
DIM
HB
HD
CLASS LT.
15A
CL
10w
CR
CLASS LT.
NO. & GR.
15A
NO
GROUND LT.
NUMBER LT.
GA LT.
15A
GA
100w
160w
C.B. PANEL LT.
100w
25w
CONT. IND. LT.
TL
2w
24w
RG
SP. REC. LT.
ENG.'S INST. PANEL
EL
NL
#2 POWER TRANSMISSION
#2 BATT. CHG. & ENG. COOLING
LIGHTING

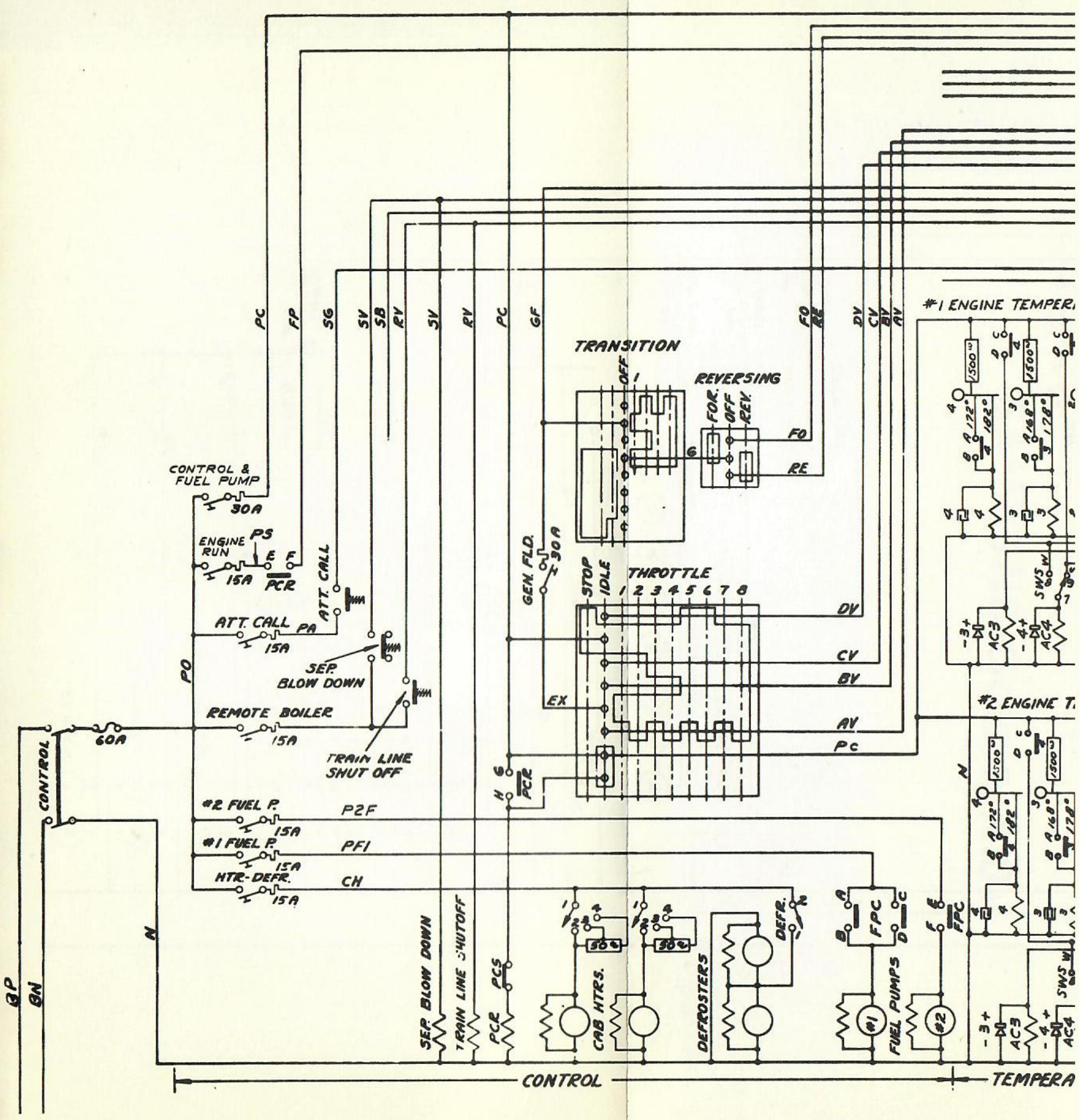

HB
BRT.
HD
DIM
PH
HDLT.
30A
HP
CL
CLASS LT.
15A
NO
NO.6 GR.
15A
GA
GA. LT.
15A
PE
LIGHTS
30A
LSF
LSR
ELS
FLS
HLS
10w
GROUND LT.
G
N
NUMBER LT.
GA
C.B. PANEL LT.
160w
25w
TL
CONT. IND. LT.
100w
100w
GA
SP. REC. LT.
RG
2w
24w
ENG'S INST. PANEL
GA
EL
V
D
E
GR
CLASS LT.
CL
ENG'S LT.
C
FIREMAN'S LT.
HOOD LT.
H
NL
LIGHTING

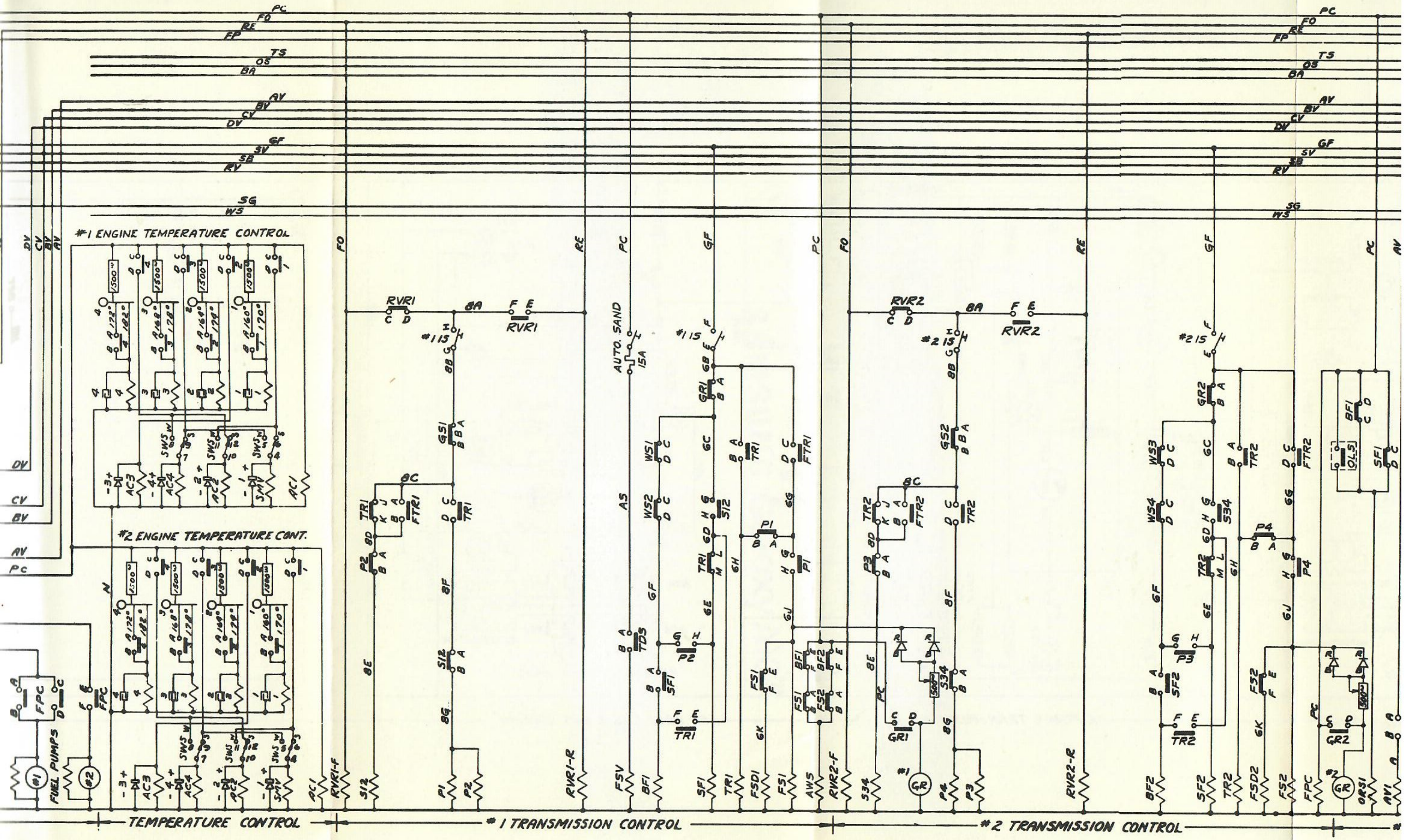

PC-13
FO-8
RE-9
FP-16
TS-5
OS-1
BA-11
SN-14
AV-15
BV-12
CV-7
DV-3
GF-6
SV-26
SB-25
RV-27
B-17
BG-21
SG-2
WS-10
S60-22
S58-19
S57-18
S59-20
SA-23
S62-24
N-4
FP
SG
WS
PC
SG
SA
B A
WS1
B A
WS2
B A
WS3
A B
AWS
WS
B A
WS4
BA
BOILER ALARM
BOILER ALARM
NVR1
C D
#1
NP
#1
OS
LOS1
#2
OS
LOS2
#1
TS
B A
ETS1
A C
ETS1
#2
TS
B A
ETS2
A C
ETS2
#213
SS
OP
ER2
G H
NVR2
C D
#2
NP
A B
NVR2
GR2
F E
ER2
#1 ALARM BELL
#2 ALARM BELL
PCR
D C
PCS OPEN
TDS
ALARM

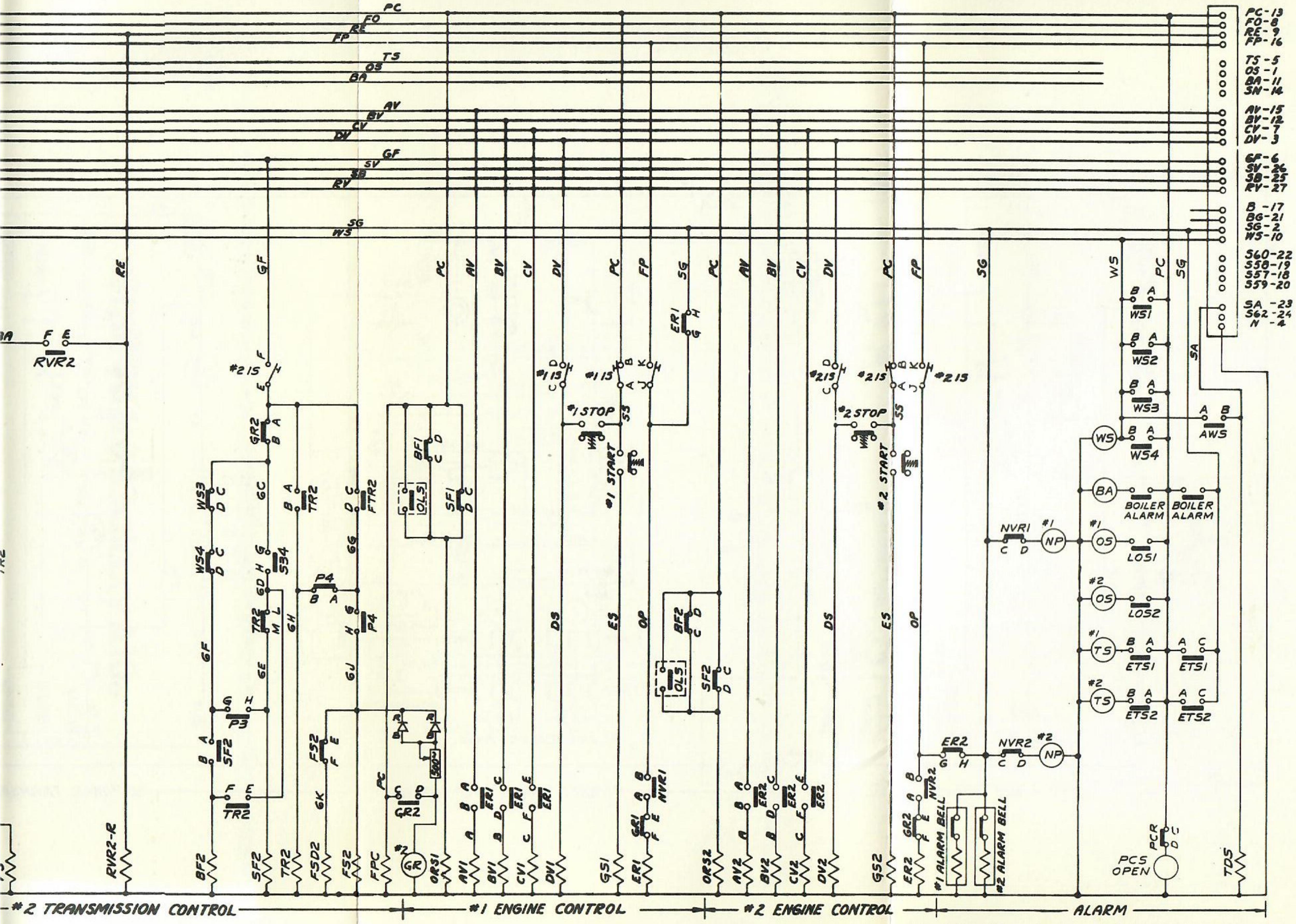
SCHEMATIC BASIC WIRING DIAGRAM
E9 LOCOMOTIVE — NON-DYNAMIC

Electrical Symbols

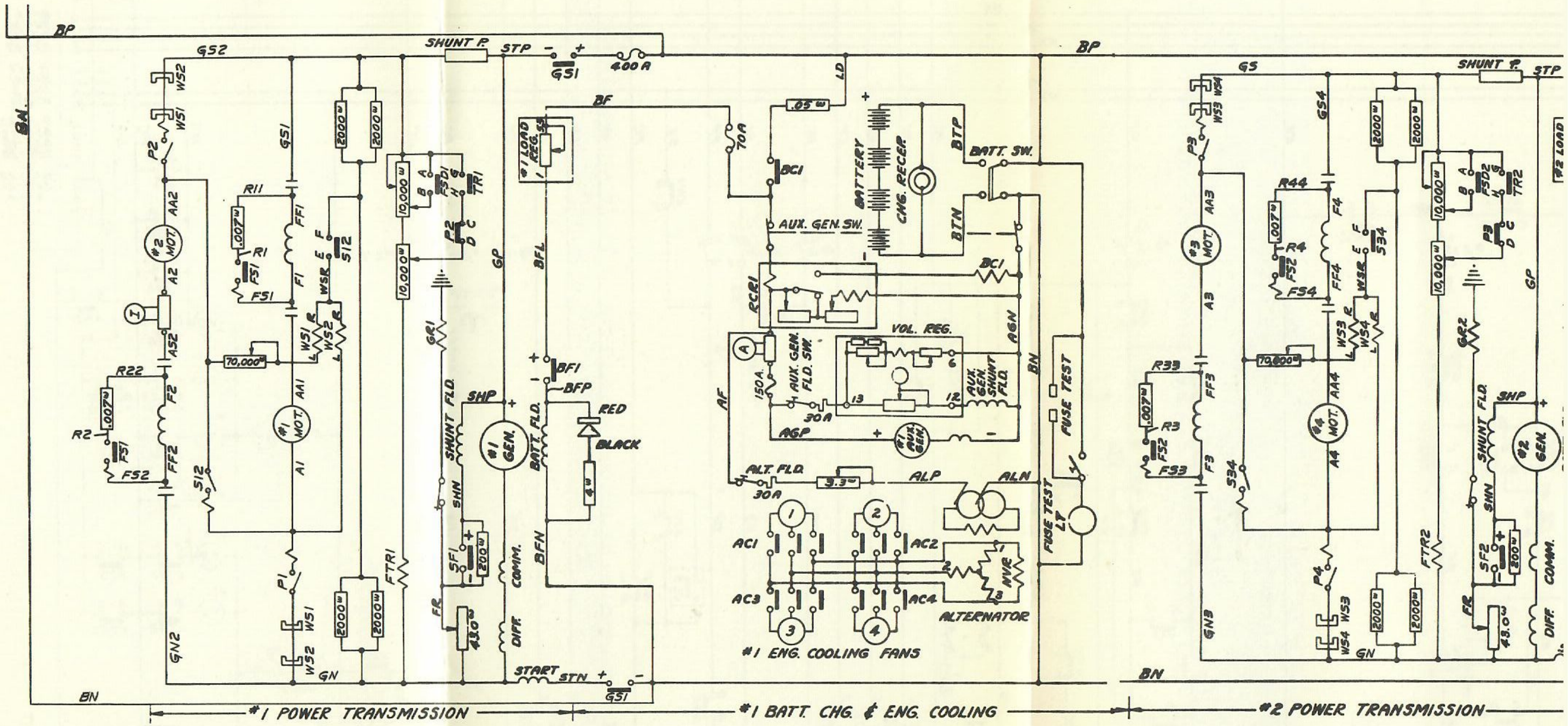

GENERATOR OR MOTOR ARMATURE
THREE PHASE INDUCTION MOTOR OR GENERATOR
DRUM TYPE SWITCH
REVERSER CONTACTORS & SERIES FIELD
CONTACTOR WITH PERM. MAG. BLOWOUT
OPERATING COILS
Series
Shunt
GROUND CONNECTION
CAPACITOR
RECTIFIER-Shows Current Direction
BATTERY
BATTERY CHARGE RECEPTACLE
LAMP
THRU CABLE RELAY
S.P.
D.P.
KNIFE SWITCHES
S.P.D.T.
D.P.D.T.
ROTARY SNAP SWITCH
N.O.
N.C.
COMPENSATING FIELD
COMMUTATING FIELD
SERIES FIELD
SHUNT OR SEPARATELY EXCITED FIELD
ALARM BELL
PUSH BUTTON SWITCH
POWER CONDUCTOR
CONTROL CONDUCTOR
WIRES CONNECTED
WIRES NOT CONNECTED
FUSE TESTER
10A
FUSE (10 AMP)
A
AMMETER WITH SHUNT
FIXED RESISTOR
RESISTOR-FIXED TAPS
RESISTOR-ADJUSTABLE TAP
THERMAL ELEMENT
RHEOSTAT
MERCURY TUBE THERMOSTAT
BACKUP LIGHT OUTLET
UTILITY OUTLET
THERMAL TRIP AIR CIRCUIT BREAKER
N.O.
N.C.
DOUBLE BREAK CONTROL CONTACTS
N.O.
N.C.
SINGLE BREAK POWER CONTACTORS
PUSH-PULL SWITCH

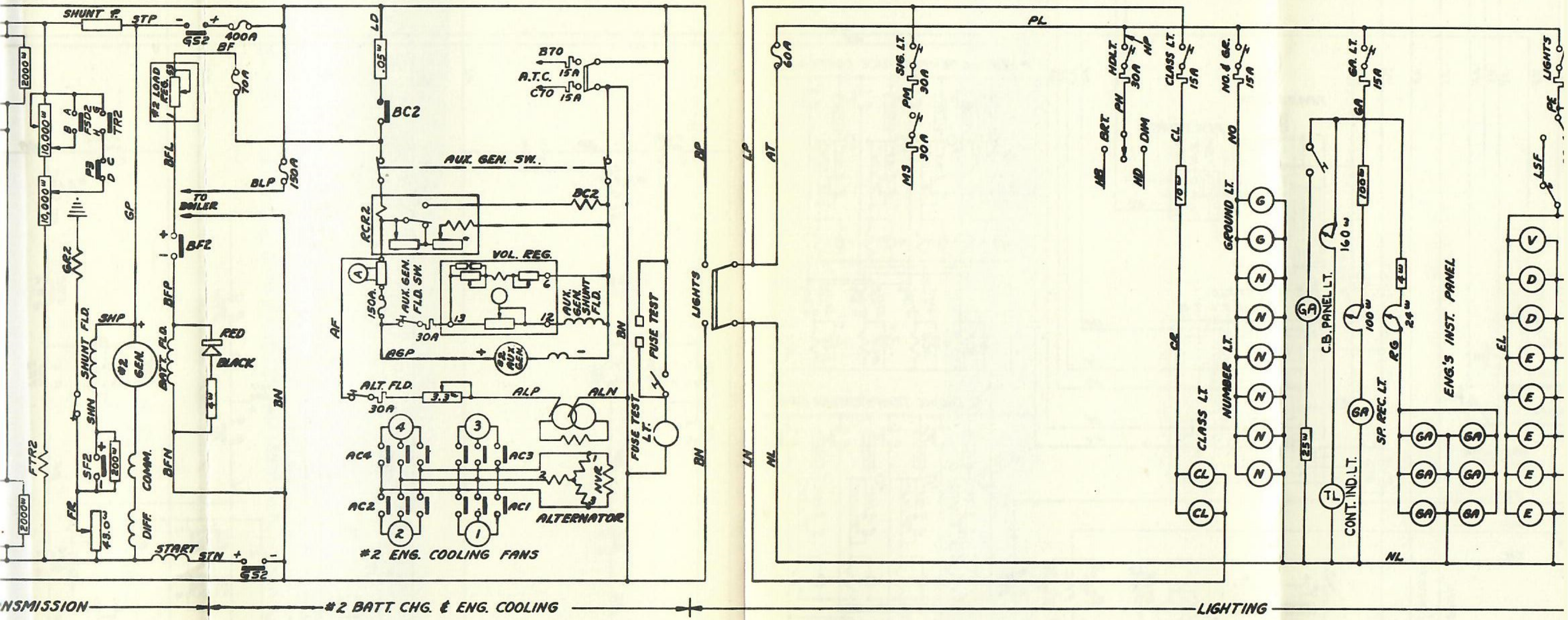

PC
FP
SG
SV
SB
RV
SV
RV
PC
GF
FO
RE
DV
CV
BV
AV
#1 ENGINE TEMPER
TRANSITION
OFF
1
REVERSING
FOR.
OFF
REV.
G
FO
RE
CONTROL & FUEL PUMP
30A
ENGINE RUN
PS
E
F
15A
PCR
ATT. CALL
ATT. CALL
PA
15A
SEP. BLOW DOWN
PO
REMOTE BOILER
15A
TRAIN LINE SHUT OFF
60A
CONTROL
GEN. FLD.
30A
STOP
IDLE
THROTTLE
1 2 3 4 5 6 7 8
EX
DV
CV
BV
AV
PC
#2 ENGINE T
G
H
PCR
#2 FUEL P.
15A
P2F
#1 FUEL P.
15A
PFI
HTR-DEFR.
15A
CH
N
N
BP
BN
SEP. BLOW DOWN
TRAIN LINE SHUTOFF
PCS
PCR
CAB HTRS.
50%
50%
DEFROSTERS
DEFR.
A
B
FPC
C
D
E
F
FPC
#1
FUEL PUMPS
#2
1500Ω
172°
182°
168°
178°
AC3
AC4
SWS
CONTROL
TEMPERA

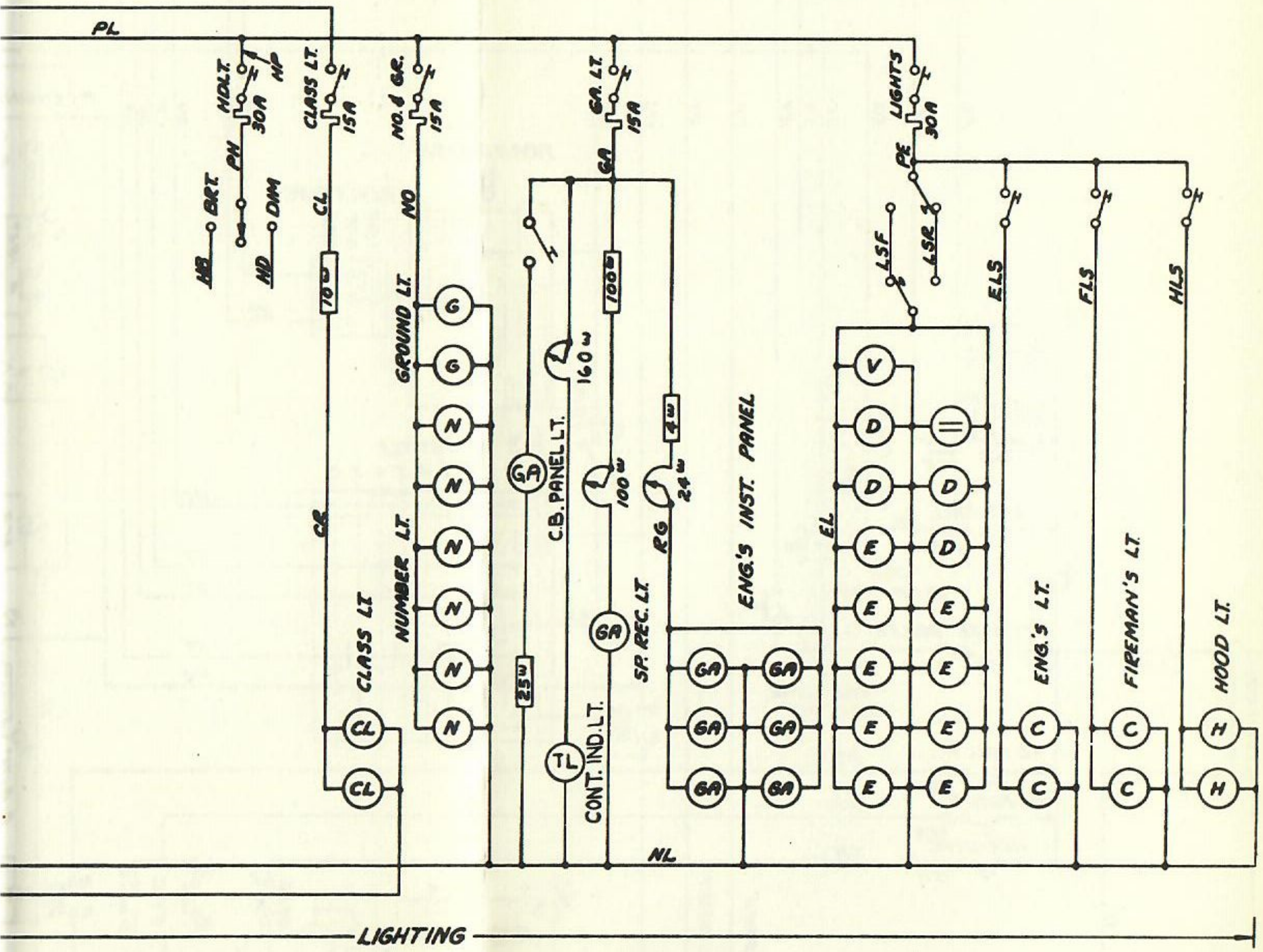

PC
FO
RE
FP
TS
OS
BA
AV
BV
CV
DV
GF
SV
SB
RV
SG
WS
#1 ENGINE TEMPERATURE CONTROL
#2 ENGINE TEMPERATURE CONT.
SWS
AC1
AC2
AC3
AC4
SMV
FPC
FUEL PUMPS
#1
#2
RVR1
RVR2
8A
8B
8C
8D
8E
8F
8G
#1 15
#2 15
AUTO. SAND
15A
GR1
GR2
GS1
GS2
TR1
TR2
FTR1
FTR2
WS1
WS2
WS3
WS4
S12
S34
P1
P2
P3
P4
TDS
SF1
SF2
FS1
FS2
FSD1
FSD2
BF1
BF2
AS
AWS
FSV
GR
OLS
ORS1
AV1
RVR1-F
RVR1-R
RVR2-F
RVR2-R
500Ω
1500Ω
TEMPERATURE CONTROL
#1 TRANSMISSION CONTROL
#2 TRANSMISSION CONTROL


PC-13
FO-8
RE-9
FP-16
TS-5
OS-1
BA-11
SN-14
AV-15
BV-12
CV-7
DV-3
GF-6
SV-26
SB-25
RV-27
B-17
BG-21
SG-2
WS-10
S60-22
S58-19
S57-18
S59-20
SA-23
S62-24
N-4
PC
FO
RE
FP
TS
OS
BA
AV
BV
CV
DV
GF
SV
SB
RV
SG
WS
RVR2
#2 15
GR2
WS3
WS4
TR2
FTR2
S34
P4
P3
SF2
FS2
GR2
BF1
OLS
SF1
#2 GR
#1 15
#1 STOP
#1 START
ER1
NVR1
GR1
BF2
SF2
#2 15
#2 STOP
#2 START
ER2
NVR2
#1 ALARM BELL
#2 ALARM BELL
NVR1
#1 NP
ER2
NVR2
#2 NP
WS1
WS2
WS3
WS4
WS
AWS
BA
BOILER ALARM
BOILER ALARM
#1 OS
LOS1
#2 OS
LOS2
#1 TS
ETS1
ETS1
#2 TS
ETS2
ETS2
PCR
PCS OPEN
RVR2-R
BF2
SF2
TR2
FSD2
FS2
FPC
ORS1
AV1
BV1
CV1
DV1
GS1
ER1
ORS2
AV2
BV2
CV2
DV2
GS2
ER2
TDS
DS
ES
OP
#2 TRANSMISSION CONTROL
#1 ENGINE CONTROL
#2 ENGINE CONTROL
ALARM

SCHEMATIC BASIC WIRING DIAGRAM
E9 LOCOMOTIVE — NON-DYNAMIC


BP
BN
GS2
WS2
WS1
P2
AA2
#2 MOT.
A2
AS2
R22
F2
FF2
.007
R2
FS1
FS2
GN2
GS1
R11
FF1
R1
FS1
F1
70,000
WS1
WS2
WSR
S12
#1 MOT.
AA1
A1
P1
W51
WS2
GN
2000
10,000
FSD1
TR1
P2
FTR1
GR1
SHUNT FLD.
SHN
SF1
200
FR
43.0
SHUNT P.
STP
GS1
400 A
GP
SHP
#1 GEN.
COMM.
DIFF.
START
STN
BF
#1 LOAD REG.
BFL
BF1
BFP
RED
BLACK
BATT. FLD.
4
BFN
LD
.05
70A
BC1
BATTERY
CHG. RECEP.
BTP
BATT. SW.
BTN
AUX. GEN. SW.
RCR1
BC1
AGN
VOL. REG.
AUX. GEN. FLD. SW.
AUX. GEN. SHUNT FLD.
150A
30A
A
AF
AGP
#1 AUX. GEN.
BN
FUSE TEST
FUSE TEST LT
ALT. FLD.
3.3
ALP
ALN
30A
AC1
AC2
AC3
AC4
NVR
ALTERNATOR
#1 ENG. COOLING FANS
GS
WS3
WS4
P3
AA3
#3 MOT.
A3
GS4
R44
F4
FF4
R4
FS2
FS4
S34
R33
FF3
R3
FS3
F3
S34
#4 MOT.
AA4
A4
P4
GN3
FSD2
TR2
FTR2
GR2
SHUNT FLD.
SHN
SF2
300
43.0
SHP
#2 GEN.
COMM.
DIFF.
#2 LOAD
#1 POWER TRANSMISSION
#1 BATT. CHG. & ENG. COOLING
#2 POWER TRANSMISSION


SHUNT P.
STP
400A
GS2
BF
70A
#2 LOAD REG.
2000W
10,000W
FSD2
TR2
P3
GP
GR2
BFL
BLP
150A
TO BOILER
BF2
SHP
SHUNT FLD.
#2 GEN.
BATT. FLD.
BFP
RED
BLACK
SHN
SF2
200W
COMM.
FTR2
FR
45.0W
DIFF.
BFN
BN
START
STN
GS2
LD
.05W
BC2
B70
A.T.C.
CTO
15A
AUX. GEN. SW.
RCR2
BC2
VOL. REG.
A
150A
AUX. GEN. FLD. SW.
30A
13
12
AUX. GEN. SHUNT FLD.
AF
AGP
#2 AUX. GEN.
ALT. FLD.
3.3W
ALP
ALN
AC4
AC3
AC2
AC1
NVR
ALTERNATOR
#2 ENG. COOLING FANS
FUSE TEST
FUSE TEST LT.
LIGHTS
BP
LP
AT
LN
NL
PL
60A
SIG. LT.
PM
MS
30A
HDLT.
PH
BRT.
DIM
HB
HD
HP
CLASS LT.
CL
70W
CR
CLASS LT.
NO. & GR.
15A
NO
GROUND LT.
NUMBER LT.
GA. LT.
GA
160W
100W
C.B. PANEL LT.
24W
SP. REC. LT.
RG
25W
CONT. IND. LT.
TL
ENG.'S INST. PANEL
LIGHTS
PE
LSF
EL
V
D
E
G
N
NL
NSMISSION
#2 BATT. CHG. & ENG. COOLING
LIGHTING


PL
HD.LT.
30A
HP
PH
BRT.
DIM
HB
HD
CLASS LT.
15A
CL
70w
CR
CLASS LT
CL
CL
NO. & GR.
15A
NO
GROUND LT.
G
G
N
N
N
N
N
N
NUMBER LT.
GA LT.
15A
GA
160w
C.B. PANEL LT.
GA
25w
TL
CONT. IND. LT.
100w
100w
GA
SP. REC. LT.
4w
24w
RG
ENG'S INST. PANEL
GA
GA
GA
GA
GA
GA
LIGHTS
30A
PE
LSF
LSR
EL
V
D
D
D
D
E
E
E
E
E
E
E
E
E
E
ELS
FLS
HLS
ENG'S LT.
FIREMAN'S LT.
HOOD LT.
C
C
C
C
H
H
NL
LIGHTING